

# DATA SHEET

## **82B715** I<sup>2</sup>C bus extender

Preliminary specification  
Supersedes data of 1997 Apr 07  
IC20 Data Handbook

1998 Jan 09

# I<sup>2</sup>C bus extender

# 82B715

## DESCRIPTION

The 82B715 is a bipolar integrated circuit intended for application in I<sup>2</sup>C bus systems.

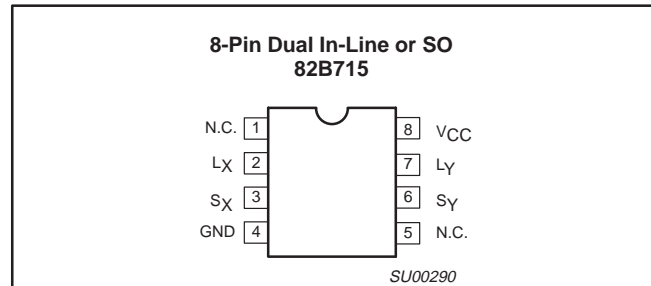
While retaining all the operating modes and features of the I<sup>2</sup>C system it permits extension of the practical separation distance between components on the I<sup>2</sup>C bus by buffering both the data (SDA) and the clock (SCL) lines.

The I<sup>2</sup>C bus capacitance limit of 400pF restricts practical communication distances to a few meters. Using one 82B715 at each end of longer cables reduces the cable loading capacitance on the I<sup>2</sup>C bus by a factor of 10 times and may allow the use of low cost general purpose wiring to extend bus lengths.

## FEATURES

- Dual, bi-directional, unity voltage gain buffer
- I<sup>2</sup>C bus compatible
- Logic signal levels may include both supply and ground
- X10 impedance transformation
- Wide supply voltage range

## PIN CONFIGURATIONS



## PINNING

| PIN | SYMBOL          | FUNCTION                         |
|-----|-----------------|----------------------------------|
| 1   | N.C.            |                                  |
| 2   | L <sub>X</sub>  | Buffered Bus, LDA or LCL         |
| 3   | S <sub>X</sub>  | I <sup>2</sup> C Bus, SDA or SCL |
| 4   | GND             | Negative Supply                  |
| 5   | N.C.            |                                  |
| 6   | S <sub>Y</sub>  | I <sup>2</sup> C Bus, SCL or SDA |
| 7   | L <sub>Y</sub>  | Buffered Bus, LCL or LDA         |
| 8   | V <sub>CC</sub> | Positive Supply                  |

## QUICK REFERENCE DATA

| SYMBOL                            | PARAMETER                | LIMITS |      |                 | UNIT |
|-----------------------------------|--------------------------|--------|------|-----------------|------|
|                                   |                          | MIN.   | TYP. | MAX.            |      |
| V <sub>CC</sub>                   | Supply voltage           | 4.5    |      | 12              | V    |
| I <sub>CC</sub>                   | Quiescent current        |        | 16   |                 | mA   |
| I <sub>line</sub>                 | Output sink capability   | 30     |      |                 | mA   |
| V <sub>in</sub>                   | Input voltage range      | 0      |      | V <sub>CC</sub> | V    |
| V <sub>out</sub>                  | Output voltage range     | 0      |      | V <sub>CC</sub> | V    |
| Z <sub>in</sub> /Z <sub>out</sub> | Impedance transformation | 8      | 10   | 13              |      |
| T <sub>amb</sub>                  | Temperature range        | -40    |      | +85             | °C   |

## ORDERING INFORMATION

| DESCRIPTION                         | ORDER CODE | DRAWING NUMBER |
|-------------------------------------|------------|----------------|
| 8-pin plastic dual In-line package  | P82B715P N | SOT97-1        |
| 8-pin plastic small outline package | P82B715T D | SOT96-1        |

## NOTE:

1. For applications requiring, 3V operation and additional buffer performance, see P82B96 Data Sheet.

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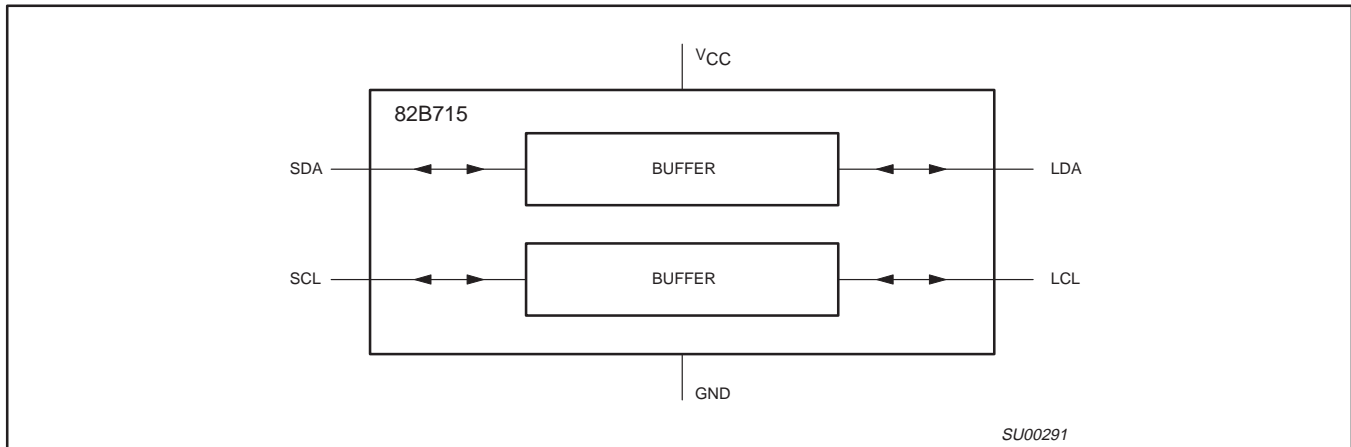


Figure 1. Block Diagram: 82B715

# I<sup>2</sup>C bus extender

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## FUNCTIONAL DESCRIPTION

The 82B715 bipolar integrated circuit contains two identical buffer circuits which enable I<sup>2</sup>C and similar bus systems to be extended over long distances without degradation of system performance or requiring the use of special cables.

The buffer has an effective current gain of ten from I<sup>2</sup>C bus to Buffered bus. Whatever current is flowing out of the I<sup>2</sup>C bus side, ten times that current will be flowing into the Buffered bus side (see Figure 2).

As a consequence of this amplification the system is able to drive capacitive loads up to ten times the standard limit on the Buffered bus side. This current based buffering approach preserves the bi-directional, open-collector/open-drain characteristic of the I<sup>2</sup>C SDA/SCL lines.

To minimize interference and ensure stability, current rise and fall rates are internally controlled.

## APPLICATION NOTES

By using two (or more) 82B715 ICs, a sub-system can be built which retains the interface characteristics of an I<sup>2</sup>C device so that it may be included in, or optionally added to, any I<sup>2</sup>C or related system.

The sub-system features a low impedance or "Buffered" bus, capable of driving large wiring capacities (see Figure 3).

### I<sup>2</sup>C Systems

As with the standard I<sup>2</sup>C system, pull-up resistors are required to provide the logic HIGH levels on the Buffered bus. (Standard open-collector configuration of the I<sup>2</sup>C bus). The size and number of these pull-up resistors depends on the system.

If the buffer is to be permanently connected into the system, the circuit should be configured with only one pull-up resistor on the Buffered bus and none on the I<sup>2</sup>C bus.

Alternatively a buffer may be connected to an existing I<sup>2</sup>C system. In this case the Buffered bus pull-up will act in parallel with the I<sup>2</sup>C bus pull-up.

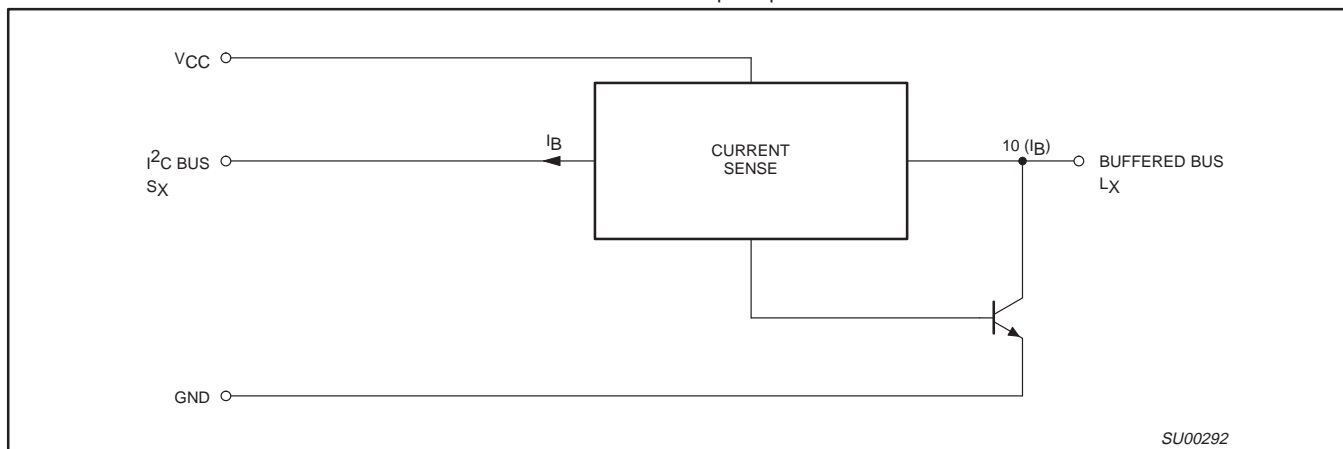


Figure 2. Equivalent Circuit: One Half 82B715

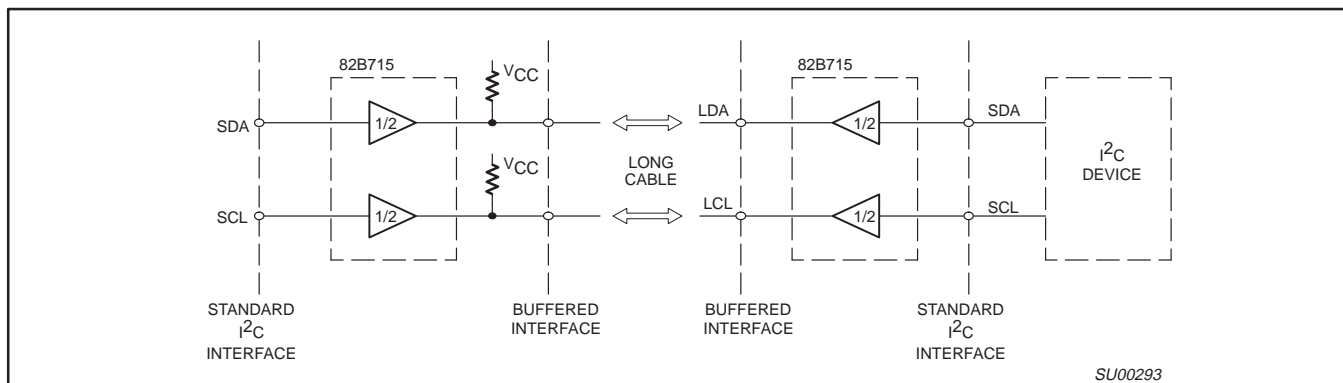


Figure 3. Minimum Sub-System with 82B715

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**RATINGS**

Limiting values in accordance with the Absolute Maximum System (IEC 134).  
 Voltages with respect to pin GND (DIL-8 pin 4).

| SYMBOL                 | PARAMETER                                      | LIMITS |                 | UNIT |
|------------------------|--|--------|-----------------|------|
|                        |  | MIN.   | MAX.            |      |
| V <sub>CC</sub> to GND | Supply voltage range V <sub>CC</sub>           | -0.3   | +12             | V    |
| V <sub>bus</sub>       | Voltage range I <sup>2</sup> C Bus, SCL or SDA | 0      | V <sub>CC</sub> | V    |
| V <sub>buff</sub>      | Voltage range Buffered Bus                     | 0      | V <sub>CC</sub> | V    |
| I                      | DC current (any pin)                           |        | 60              | mA   |
| P <sub>tot</sub>       | Power dissipation                              |        | 300             | mW   |
| T <sub>stg</sub>       | Storage temperature range                      | -55    | +125            | °C   |
| T <sub>amb</sub>       | Operating ambient temperature range            | -40    | +85             | °C   |

**CHARACTERISTICS**

At T<sub>amb</sub> = +25°C and V<sub>CC</sub> = 5 Volts, unless otherwise specified.

| SYMBOL                            | PARAMETER   | LIMITS |      |      | UNIT |
|-----------------------------------|---|--------|------|------|------|
|                                   |   | MIN.   | TYP. | MAX. |      |
| <b>Power Supply</b>               |   |        |      |      |      |
| V <sub>CC</sub>                   | Supply voltage (operating)  | 4.5    | —    | 12   | V    |
| I <sub>CC</sub>                   | Supply current  | —      | 16   | —    | mA   |
| I <sub>CC</sub>                   | Supply current at V <sub>CC</sub> = 12V   | —      | 22   | —    | mA   |
| I <sub>CC</sub>                   | Supply current, both I <sup>2</sup> C inputs LOW,<br>both buffered outputs sinking 30mA.  | —      | 28   | —    | mA   |
| <b>Drive Currents</b>             |   |        |      |      |      |
| I <sub>Sx</sub> , I <sub>Sy</sub> | Output sink on I <sup>2</sup> C bus<br>V <sub>Sx</sub> , V <sub>Sy</sub> LOW = 0.4V<br>V <sub>Lx</sub> , V <sub>Ly</sub> LOW on Buffered bus = 0.3V | 3      | —    | —    | mA   |
| I <sub>Lx</sub> , I <sub>Ly</sub> | Output sink on Buffered bus<br>V <sub>Lx</sub> , V <sub>Ly</sub> LOW = 0.4V<br>V <sub>Sx</sub> , V <sub>Sy</sub> LOW on I <sup>2</sup> C bus = 0.3V | 30     | —    | —    | mA   |
| <b>Input Currents</b>             |   |        |      |      |      |
| I <sub>Sx</sub> , I <sub>Sy</sub> | Input current from I <sup>2</sup> C bus when<br>I <sub>Lx</sub> , I <sub>Ly</sub> sink on Buffered bus = 30mA                                       | —      | —    | 3    | mA   |
| I <sub>Lx</sub> , I <sub>Ly</sub> | Input current from Buffered bus when<br>I <sub>Sx</sub> , I <sub>Sy</sub> sink on I <sup>2</sup> C bus = 3mA  | —      | —    | 3    | mA   |
| I <sub>Lx</sub> , I <sub>Ly</sub> | Leakage current on Buffered bus<br>V <sub>Lx</sub> , V <sub>Ly</sub> = V <sub>CC</sub> , and V <sub>Sx</sub> , V <sub>Sy</sub> = V <sub>CC</sub>    | —      | —    | 200  | μA   |
| <b>Impedance Transformation</b>   |   |        |      |      |      |
| Z <sub>in</sub> /Z <sub>out</sub> | Input/Output impedance  | 8      | 10   | 13   |      |

**Pull-Up Resistance Calculation**

In calculating the pull-up resistance values, the gain of the buffer introduces scaling factors which must be applied to the system components. Viewing the system from the Buffered bus, all I<sup>2</sup>C bus capacitances have effectively 10 times their I<sup>2</sup>C bus value.

In practical systems the pull-up resistance is determined by the rise time limit for I<sup>2</sup>C systems. As an approximation this limit will be satisfied if the time constant (product of the net resistance and net capacitance) of the total system is set to 1 microsecond.

The total time constant may either be set by considering each bus node individually (i.e., the I<sup>2</sup>C nodes, and the Buffered bus node) and choosing pull-up resistors to give time constants of 1 microsecond for each node; or by combining the capacitances into an equivalent capacitive loading on the Buffered bus, and

calculating the Buffered bus pull-up resistor required by this equivalent capacitance.

For each separate bus the pull-up resistor may be calculated as follows:

$$R = \frac{1 \mu \text{sec}}{C_{\text{device}} + C_{\text{wiring}}}$$

Where: C<sub>device</sub> = sum of device capacitances connected to each bus,

and C<sub>wiring</sub> = total wiring and stray capacitance on each bus.

If these capacitances are not known then a good approximation is to assume that each device presents 10pF of load capacitance and 10pF of wiring capacitance.

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The capacitance figures for one or more individual I<sup>2</sup>C bus nodes should be multiplied by a factor of 10 times, and then added to the Buffered bus capacitance. Calculation of a new Buffered bus pull-up resistor will allow this single pull-up resistor to act for both the included I<sup>2</sup>C bus nodes and the Buffered bus. Thus it is possible to combine some or all of these separate pull-up resistors into a single resistor on the Buffered bus (the value of which is calculated from the sum of the scaled capacitances on the Buffered bus). If the buffer is to be permanently connected into the system then all the separate pull-up resistors should be combined. But if it is to be connected by adding it onto an existing system, then only those on the additional I<sup>2</sup>C bus system can be combined onto the Buffered bus if the original system is required to be able to still operate on a stand-alone basis.

A further restriction is that the maximum pull-up current, with the bus LOW, should not exceed the I<sup>2</sup>C bus specification maximum of 3mA, or 30mA on the Buffered bus. The following formula applies:

$$30\text{mA} > \frac{V_{CC} - 0.4}{R_P}$$

Where:  $R_P$  = scaled parallel combination of all pull-up resistors.

If this condition is met, the fall time specifications will also be met.

Figure 4 shows typical loading calculations for the expanded I<sup>2</sup>C bus.

### **Sx, Sy, I<sup>2</sup>C Bus, SDA or SCL**

Because the two buffer circuits in the 82B715 are identical either input pin can be used as the I<sup>2</sup>C Bus SDA data line, or the SCL clock line.

### **Lx, Ly, Buffered Bus, LDA or LCL**

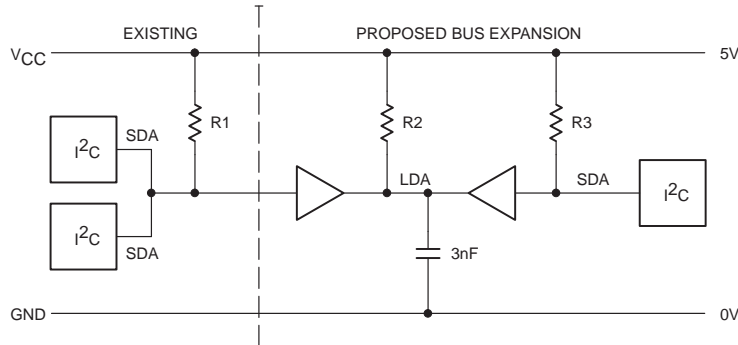
On the buffered low impedance line side, the corresponding output becomes LDA and LCL.

### **V<sub>CC</sub>, GND — Positive and Negative Supply Pins**

In normal use the power supply voltages at each end of the low impedance line should be comparable. If these differ by a significant amount, noise margin is sacrificed.

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**EFFECTIVE CAPACITANCE NEAR I<sup>2</sup>C DEVICES**

|                              |             |
|------------------------------|-------------|
| 2 × I <sup>2</sup> C Devices | 20pF        |
| Strays                       | 20pF        |
| 82B715 Buffer                | 10pF        |
| <b>TOTAL CAP.</b>            | <b>50pF</b> |

I<sup>2</sup>C pull-up

$$R1 = \frac{1\mu\text{sec}}{50\text{pF}} = 20\text{K}\Omega$$

**EFFECTIVE CAPACITANCE BUFFERED LINE**

|                   |               |
|-------------------|---------------|
| Wiring Cap.       | 3000pF        |
| <b>TOTAL CAP.</b> | <b>3000pF</b> |

Buffered Bus pull-up

$$R2 = \frac{1\mu\text{sec}}{3000\text{pF}} = 333\Omega$$

**EFFECTIVE CAPACITANCE REMOTE I<sup>2</sup>C DEVICES**

|                              |             |
|------------------------------|-------------|
| 1 × I <sup>2</sup> C Devices | 10pF        |
| Strays                       | 10pF        |
| 82B715 Buffer                | 10pF        |
| <b>TOTAL CAP.</b>            | <b>30pF</b> |

I<sup>2</sup>C pull-up

$$R3 = \frac{1\mu\text{sec}}{30\text{pF}} = 33\text{K}\Omega$$

**AS AN ADDITION TO AN EXISTING SYSTEM \* :**

R1 = 20KΩ

$$R2' = \frac{R2 \times 0.1R3}{R2 + 0.1R3} = 300\Omega$$

R3 not required since buffer always connected

**FOR A PERMANENT SYSTEM \* :**

R1 not required since buffer always connected

$$R2' = \frac{1}{\frac{1}{0.1R1} + \frac{1}{0.1R2} + \frac{1}{0.1R3}} = 262\Omega$$

R3 not required since buffer always connected

**\* NOTE:**

R1, R2 and R3 are calculated from the capacitive loading and a 1μsec time constant on each bus node. For an addition to an existing system, R2' (the new value for R2) is shown as being calculated from the parallel combination of R2 and the scaled value of R3; while for a permanent system R2, and scaled values of R1 and R3 have been used. Note that this example has used scaled resistor values and combined the node and cable capacitances.

**CHECK FOR MAXIMUM PULL-UP CURRENT:**

$$\frac{(5 - 0.4)\text{V}}{260\Omega} = 17.6\text{mA} < 30\text{mA}$$

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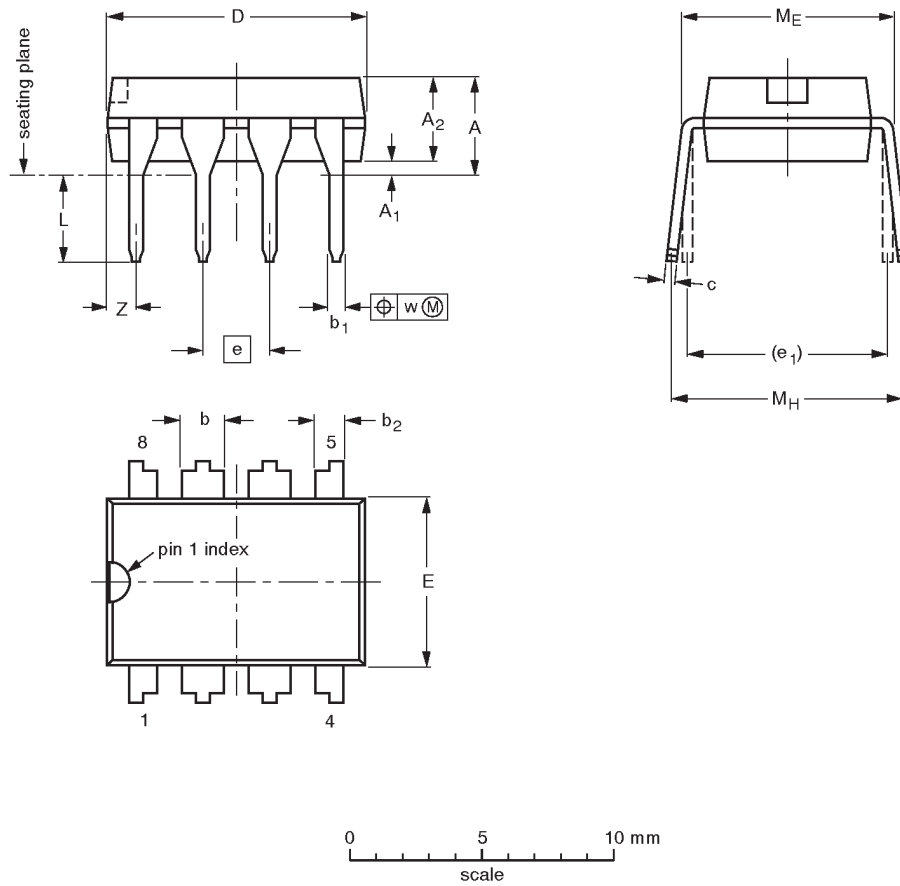
Figure 4. Typical Loading Calculation: I<sup>2</sup>C Bus with 82B715

# I<sup>2</sup>C bus extender

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**DIP8: plastic dual in-line package; 8 leads (300 mil)**

**SOT97-1**



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

| UNIT   | A max. | A <sub>1</sub> min. | A <sub>2</sub> max. | b              | b <sub>1</sub> | b <sub>2</sub> | c              | D <sup>(1)</sup> | E <sup>(1)</sup> | e    | e <sub>1</sub> | L            | M <sub>E</sub> | M <sub>H</sub> | w     | Z <sup>(1)</sup> max. |
|--------|--------|---------------------|---------------------|----------------|----------------|----------------|----------------|------------------|------------------|------|----------------|--------------|----------------|----------------|-------|-----------------------|
| mm     | 4.2    | 0.51                | 3.2                 | 1.73<br>1.14   | 0.53<br>0.38   | 1.07<br>0.89   | 0.36<br>0.23   | 9.8<br>9.2       | 6.48<br>6.20     | 2.54 | 7.62           | 3.60<br>3.05 | 8.25<br>7.80   | 10.0<br>8.3    | 0.254 | 1.15                  |
| inches | 0.17   | 0.020               | 0.13                | 0.068<br>0.045 | 0.021<br>0.015 | 0.042<br>0.035 | 0.014<br>0.009 | 0.39<br>0.36     | 0.26<br>0.24     | 0.10 | 0.30           | 0.14<br>0.12 | 0.32<br>0.31   | 0.39<br>0.33   | 0.01  | 0.045                 |

**Note**

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

| OUTLINE VERSION | REFERENCES |          |      | EUROPEAN PROJECTION | ISSUE DATE           |
|-----------------|------------|----------|------|---------------------|----------------------|
|                 | IEC        | JEDEC    | EIAJ |                     |                      |
| SOT97-1         | 050G01     | MO-001AN |      |                     | 92-11-17<br>95-02-04 |

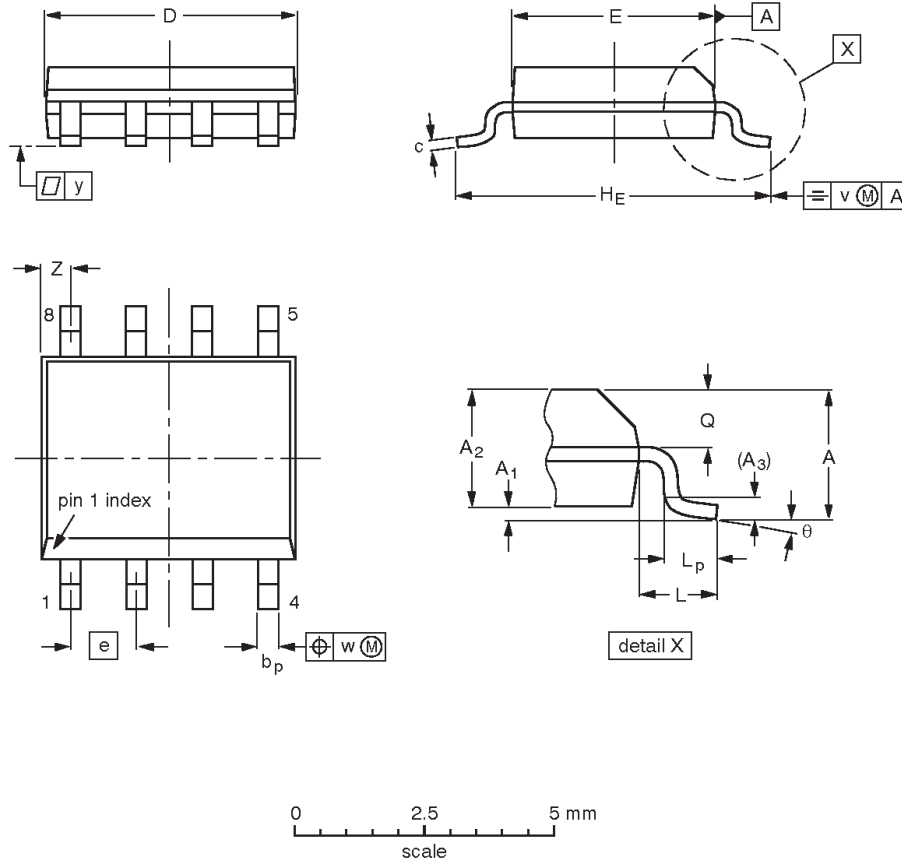


# I<sup>2</sup>C bus extender

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

**SOT96-1**



**DIMENSIONS (inch dimensions are derived from the original mm 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> | Q              | v    | w    | y     | Z <sup>(1)</sup> | $\theta$ |
|--------|--------|----------------|----------------|----------------|----------------|------------------|------------------|------------------|-------|----------------|-------|----------------|----------------|------|------|-------|------------------|----------|
| mm     | 1.75   | 0.25<br>0.10   | 1.45<br>1.25   | 0.25           | 0.49<br>0.36   | 0.25<br>0.19     | 5.0<br>4.8       | 4.0<br>3.8       | 1.27  | 6.2<br>5.8     | 1.05  | 1.0<br>0.4     | 0.7<br>0.6     | 0.25 | 0.25 | 0.1   | 0.7<br>0.3       | 8°<br>0° |
| inches | 0.069  | 0.010<br>0.004 | 0.057<br>0.049 | 0.01           | 0.019<br>0.014 | 0.0100<br>0.0075 | 0.20<br>0.19     | 0.16<br>0.15     | 0.050 | 0.244<br>0.228 | 0.041 | 0.039<br>0.016 | 0.028<br>0.024 | 0.01 | 0.01 | 0.004 | 0.028<br>0.012   |          |

**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    | EIAJ |  |                     |                      |
| SOT96-1         | 076E03S    | MS-012AA |      |  |                     | 95-02-04<br>97-05-22 |

I<sup>2</sup>C bus extender

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## Data sheet status

| Data sheet status         | Product status | Definition [1]   |
|---------------------------|----------------|--|
| Objective specification   | Development    | This data sheet contains the design target or goal specifications for product development. Specification may change in any manner without notice.  |
| Preliminary specification | Qualification  | This data sheet contains preliminary data, and supplementary data will be published at a later date. Philips Semiconductors reserves the right to make changes at any time without notice in order to improve design and supply the best possible product. |
| Product specification     | Production     | This data sheet contains final specifications. Philips Semiconductors reserves the right to make changes at any time without notice in order to improve design and supply the best possible product.   |

[1] Please consult the most recently issued datasheet before initiating or completing a design.

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**Short-form specification** — The data in a short-form specification is extracted from a full data sheet with the same type number and title. For detailed information see the relevant data sheet or data handbook.

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