

Extending I²C Communication Distance with TI I²C Extender P82B96 and P82B715



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ABSTRACT

I²C bus is widely used in electronic systems for simplicity and low cost. For example, a precise DAC with I²C interface often was used to adjust the output voltage for high voltage power supply in medical systems such as ultrasound imaging, MRI, CT and so forth. In general, I²C was used in onboard communications between master and miscellaneous slaves such as low-speed ADC, low-speed DAC, GPIO, memory, sensors, and so on. However, designers sometimes must control remote slaves with I²C interface in another board potentially ten meters away. Long cable potential means big bus capacitance. The I²C standard specifies a maximum bus capacitance of 400pF for both Standard Mode and Fast Mode and specifies 550pF for Fast Mode Plus. As a result, long cable potential means the bus capacitance is out of the specification of I²C and potentially causes more error data rates. TI released two parts (P82B96 and P82B715) to solve this problem.

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1 Introduction

I²C bus was popular in electronic system for communication between master and slaves. The maximum distance of an I²C bus depends on the capacitive loading. In typical applications, the length is limited to a few meters in standard mode. This is because a system must be built to accommodate a maximum bus capacitance of 400pF to meet rise time requirements listed in the I²C bus specification for both Standard Mode and Fast Mode and specifies 550pF for Fast Mode Plus.

In the actual project, designers often must control a remote slave at least ten meters away from the master board, and they must use long cables between I²C master and slaves. However, long cable potential means large capacitances that are out of specifications of I²C bus specification and then can cause large error data rates.

To achieve longer distances by operating above the maximum permitted bus capacitance, the I²C bus specification allows operating at a lower speed, using higher drive output devices, dividing the bus into segments with bus buffers, or the use of switched pullup circuits. While on the surface these methods seem viable, they either do not meet the long-distance requirements or significantly increase the cost. Use [P82B96](#) or [P82B715](#) I²C buffer as an alternative.

2 Methods to Extend I²C Communication Distance

[P82B96](#) and [P82B715](#) chips can be used to extend communication distances between I²C master and slaves. Both chips allow I²C bus capacitance of 400pF on the main I²C bus side and 3000pF or 4000pF on the transmission side. This performance permits [P82B96](#) and [P82B715](#) to extend I²C cables up to ten meters.

3 Extend I²C Communication Distance by P82B96

The P82B96 device is a bus buffer that supports bidirectional data transfer between an I²C bus and a range of other bus configurations with different voltage and current levels. One of the advantages of the P82B96 is that this chip supports longer cables and traces and allows for more devices per I²C bus because this can isolate bus capacitance such that the total loading (devices and trace lengths) of the new bus or remote I²C nodes are not apparent to other I²C buses (or nodes). Then the restrictions on the number of I²C devices in a system due to capacitance, or the physical separation between them, are greatly improved. The main feature of P82B96 is

- Operating Power-Supply Voltage Range of 2V to 15V
- Can Interface Between I²C Buses Operating at Different Logic Levels (2V to 15V)
- Longer Cables by allowing bus capacitance of 400pF on Main Side (S_x/S_y) and 4000pF on Transmission Side (T_x/T_y)
- Outputs on the Transmission Side (T_x/T_y) Have High Current Sink Capability for Driving Low- Impedance or High-Capacitive Buses
- 400kHz Fast I²C Bus Operation Over at Least 20 Meters of Wire.

Figure 3-1 shows the typical application for P82B96.

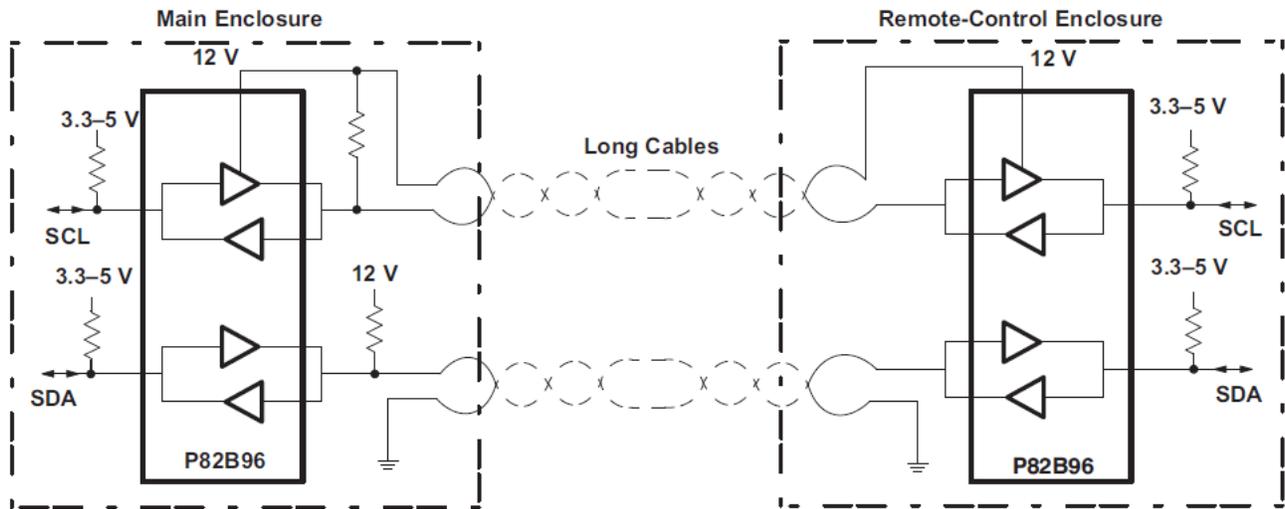


Figure 3-1. Long-Distance I²C Communications based P82B96

Note that in any design, the S_x pins P82B96 of different devices must never be linked, because the resulting system is very susceptible to induced noise and does not support all I²C operating modes. See Figure 3-2 (Pull up resistor was eliminated for the simple block figure. The following system block figure denotes the same). This means that two or more S_x or S_y I/Os of P82B96 must not be connected to each other on the same node. The P82B96 design does not support this configuration. The reason is bidirectional I²C signals do not have a direction control pin so, instead, slightly different logic low-voltage levels are used at S_x/S_y to avoid latching of this buffer.

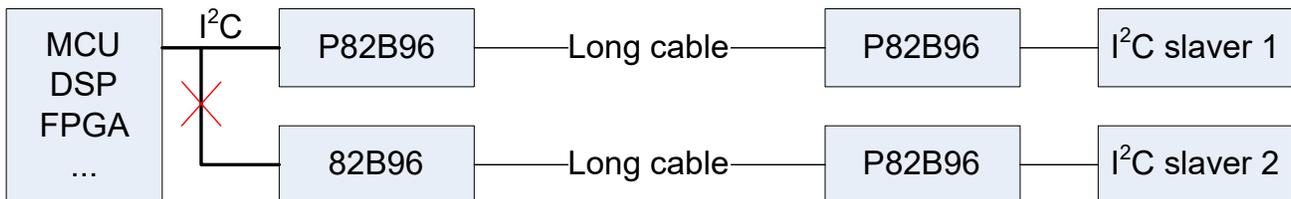


Figure 3-2. P82B96 Does Not Support S_x Pins Linked

4 Extend I²C Communication Distance by P82B715

Similar with P82B96, the P82B715 is another device for buffering highly capacitive I²C bus systems, and it supports bidirectional data transfer through the I²C bus too. The P82B715 buffers both the serial data (SDA) and serial clock (SCL) signals on the I²C bus and allows for extension of the I²C bus, while retaining all the operating modes and features of the I²C system. The main feature of P82B715 is

- Operating Power-Supply Voltage Range of 3V to 12V
- Supports Bidirectional Data Transfer of I²C Bus Signals
- Allows Bus Capacitance of 400 pF on Main I²C Bus (S_x/S_y Side) and 3000pF on Transmission Side (L_x/L_y Side)
- Dual Bidirectional Unity-Voltage-Gain Buffer with no external directional control required
- Drives 10× Lower-Impedance Bus Wiring for Improved Noise Immunity
- Multi-Drop Distribution of I²C Signals Using Low-Cost Twisted-Pair Cables
- I²C Bus Operation Over 50 Meters of Twisted-Pair Wire

The typical application for P82B715 as Figure 4-1 shows.

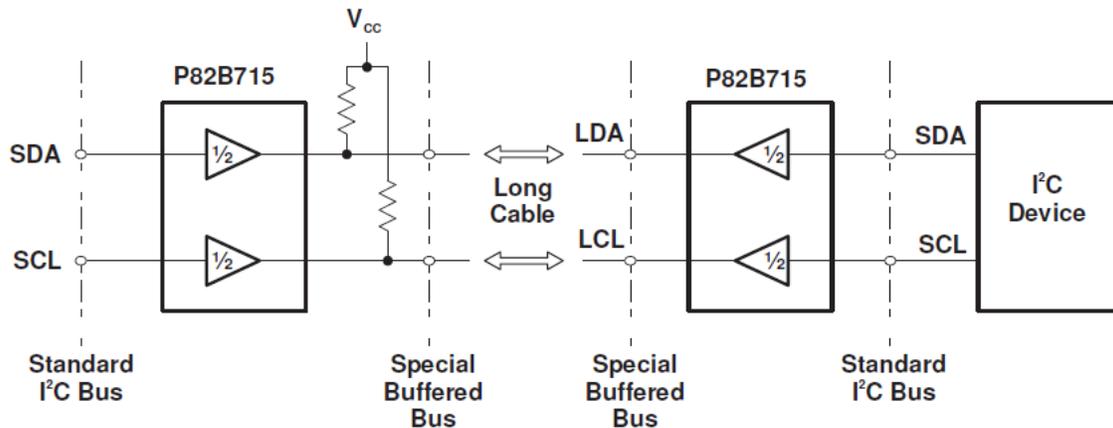


Figure 4-1. Long-Distance I²C Communications based P82B715

Compared to P82B96, two or more S_x or S_y I/Os of P82B715 can be interconnected and are also fully compatible with bus buffers that use voltage level offsets (such as the TCA9517) because this duplicates and transmits the offset voltage. See Figure 4-2 .

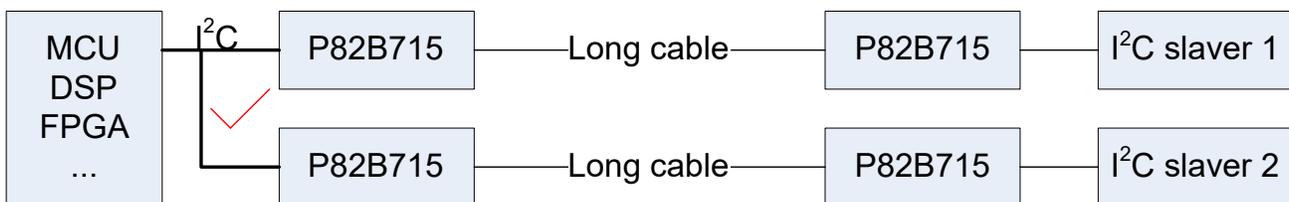


Figure 4-2. Long-Distance I²C Communications based P82B715

5 System Application

In actual applications, designers can use P82B96 or P82B715 to control remote I²C slavers. If there are two or more remote slavers on different PCBA boards, communicate with the master. The typical application can be implemented as Figure 5-1 shows. In this condition, both P82B96 or P82B715 can be used for external I²C distance since two I²C ports are available.

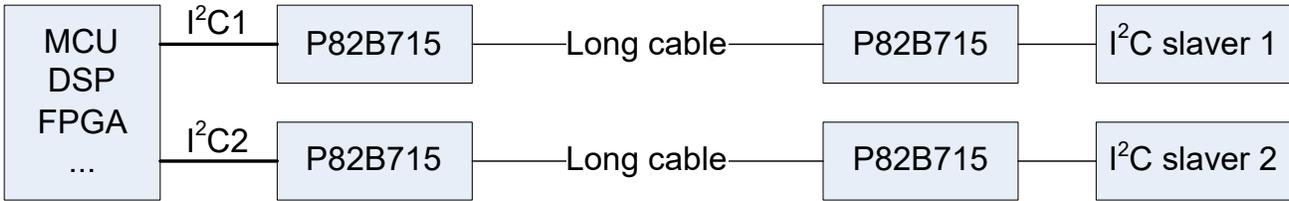


Figure 5-1. Interface with Two Remote Slavers by Two I²C Interface

If there is one I²C port in the master available, then designer must use P82B715 as Figure 4-2 configuration shows or use the configuration as Figure 5-2 shows. As Figure 5-2 shows, both P82B96 or P82B715 can be used.

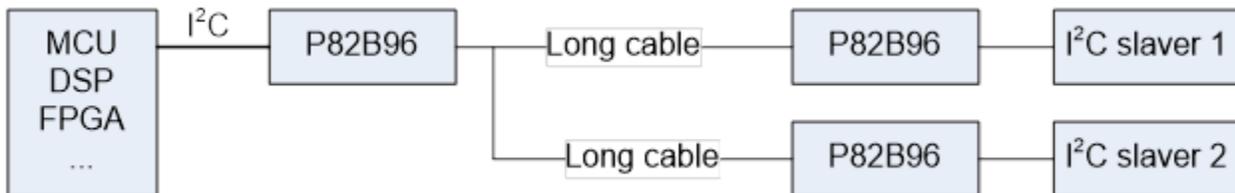


Figure 5-2. Interface with Two Remote Slavers by Two I²C Interfaces

In some applications, there can be two or more slaves located in the remote but on the same PCBA board. In this condition, P82B715 can be used to communicate with remote slavers as Figure 5-3 shows.

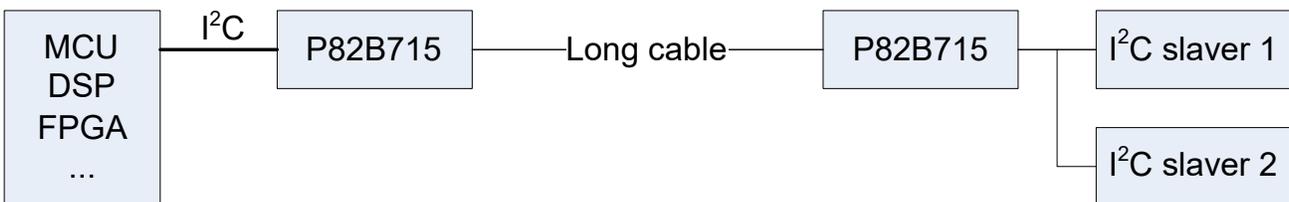


Figure 5-3. Interface with Two Remote Slavers by Two I²C Interfaces

Some designers can ask whether or not they can combine P82B96 and P82B715 in the I²C link as Figure 5-4 shows. TI does not recommend combining P82B96 and P82B715 as a pair.

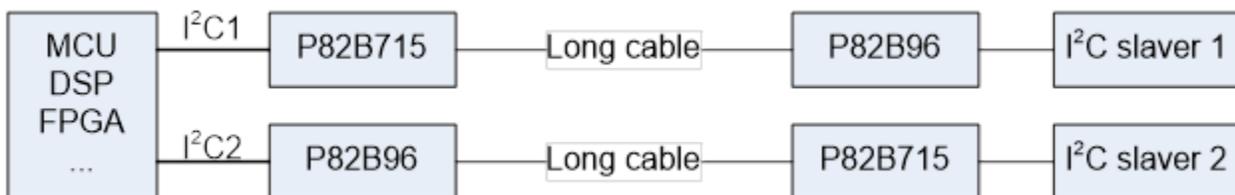


Figure 5-4. Interface with Two Remote Slavers by Two I²C Interfaces mixed P82B96 and P82B715

6 Summary

Both P82B96 and P82B715 can be used to extend an I²C bus. The advantages of the P82B96 and P82B715 is that this device supports longer cables and traces and allows for more devices per I²C bus because it can isolate bus capacitance such that the total loading (devices and trace lengths) of the new bus or remote I²C nodes are not apparent to other I²C buses (or nodes). Then, the restrictions on the number of I²C devices in a system due to capacitance, or the physical separation between them, are greatly improved. [Table 6-1](#) lists the difference between P82B96 and P82B715. Select the proper parts for an application according to function, performance, cost, package and so on.

Table 6-1. Comparison Between P82B96 and P82B715

Item	P82B96	P82B715
Power supply range	2~15V	4.5~12V
Bus capacitance on main side	400pF	400pF
Bus capacitance on transmission side	4000pF	3000pF
S _x , S _y linkable?	no	yes
Galvanic Isolation	Yes	no
package	SOIC8, VSSOP8, PDIP8, TSSOP8	SOIC8, PDIP8

7 References

1. Texas Instruments, [Understanding the I²C bus](#), application note.
2. Texas Instruments, [Why, When, and How to use I²C Buffers](#), application note.
3. Texas Instruments, [P82B715 I²C Bus Extender](#) datasheet.
4. Texas Instruments, [P82B96 I²C Bus Extender](#) datasheet.
5. Texas Instruments, [TCA9517 Level-Shifting I²C Bus Repeater](#) datasheet.
6. Texas Instruments, [A Basic Guide to I²C](#), application note.

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