LOW-COST I²C LEVEL TRANSLATOR

1. Introduction

This applications note discusses a low-cost circuit for I²C level translation. This circuit was developed for the Si701x, Si702x, and Si703x humidity sensors but will work in many applications.

This circuit provides I²C level translation from a higher voltage supply, such as 5 V, to a lower voltage, supply such as 1.8 or 3.3 V. In addition, the optional emitter follower circuit provides a low-voltage power supply rail from the higher 5 V supply.

Note that some devices allow for higher voltage tolerance on I²C inputs. For example, the Si7034 has a 3.3 V tolerant I²C interface, so the level translation is only required for 5 V I²C designs.

2. Circuit

The basic circuit is shown in Figure 1.

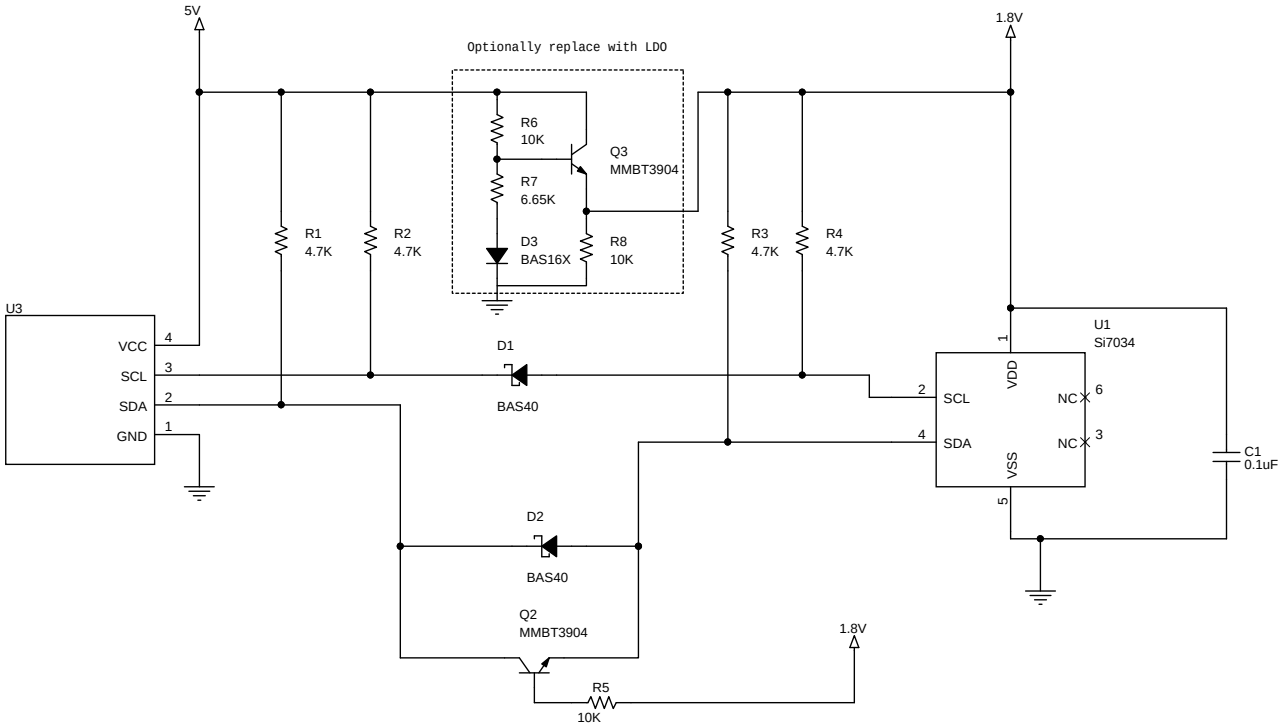


Figure 1. Low-Cost I²C Level Translator Circuit

In this case, we are translating from 5 V to 1.8 V, and the I²C speed is assumed to be sufficiently slow for clock stretching to not occur (i.e. less than 300 kHz for the Si701x, Si702x, and Si703x humidity sensors). In this case, the SCL line is unidirectional.

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For the SCL line, a Shottky diode is used to prevent the SCL line from pulling all the way high on the lower voltage device while allowing it to pull all the way high on the higher voltage device. The voltage drop across the Schottky diode must be low enough so that when the higher-voltage device pulls low, there is still a logic low on the lower-voltage device. For the Si7034 used in this case, the logic low level is 0.54 V (0.3 x VDD), and the Schottky diode drop is about 0.35 V, so there is no issue. If the lower voltage device was on a 3.3 V rail, an ordinary diode could be used.

The SDA line is bidirectional, and Q2 is added so that when the lower voltage device pulls down on SDA, SDA of the higher voltage device will pull down. In a case where clock stretching needs to be supported, SCL can be made bidirectional by adding the same transistor circuit across D1.

The emitter follower circuit is a low-cost method for providing a 1.8 V rail from the higher 5 V supply. Alternatively, this circuit can be replaced with an LDO for a simpler layout or if additional voltage regulation is required.

3. Waveforms

The circuit was tested for the case of 3.3 to 1.8 V level translation. Figure 2 shows the waveforms on the SDA line with a clean translation from 3.3 V (blue trace) to 1.8 V (yellow trace).

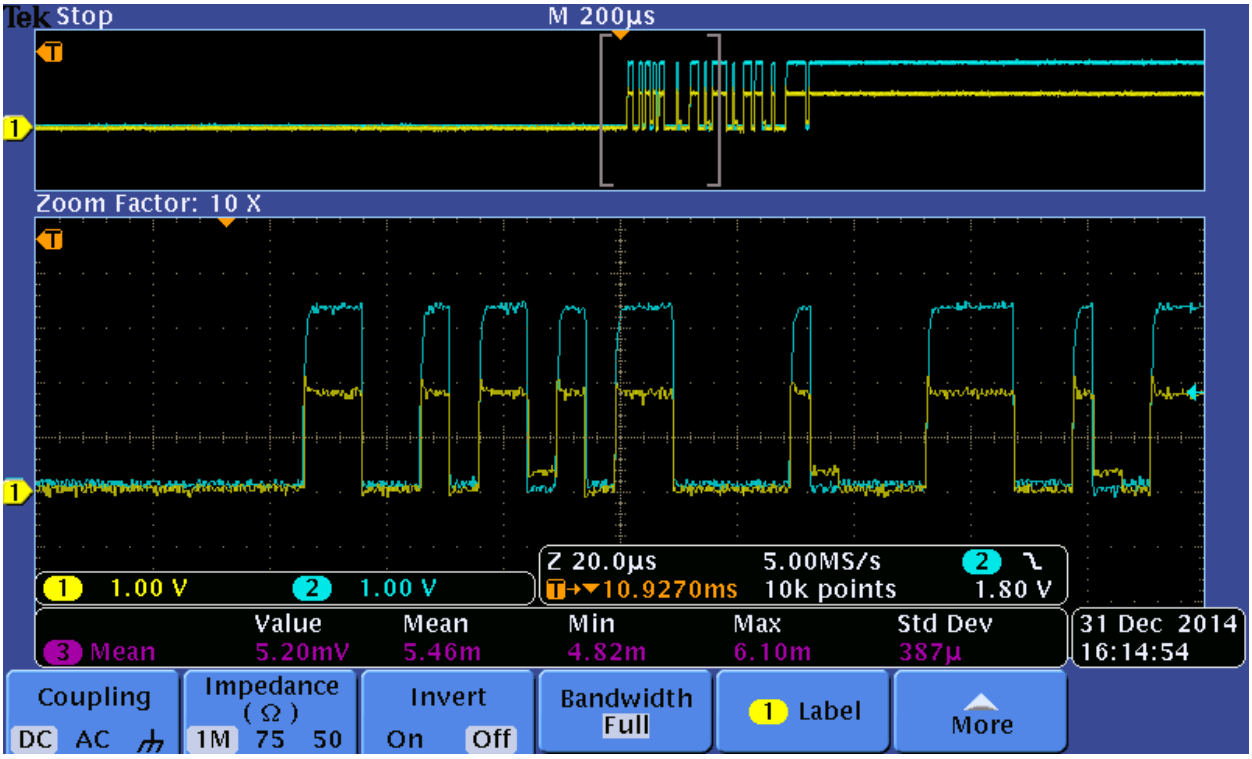


Figure 2. SDA Line at 1 V per Division

Zooming in to 200 mV per division, the circuit operation can be clearly seen in Figure 3.

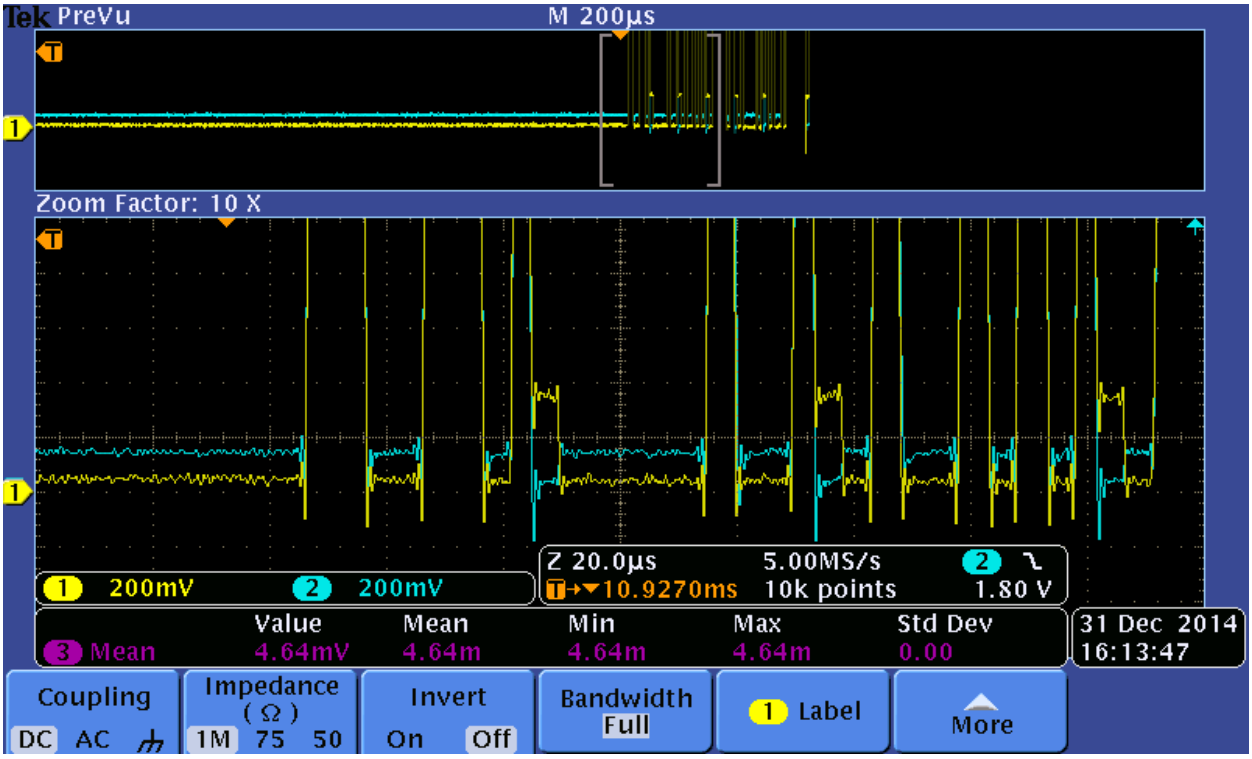
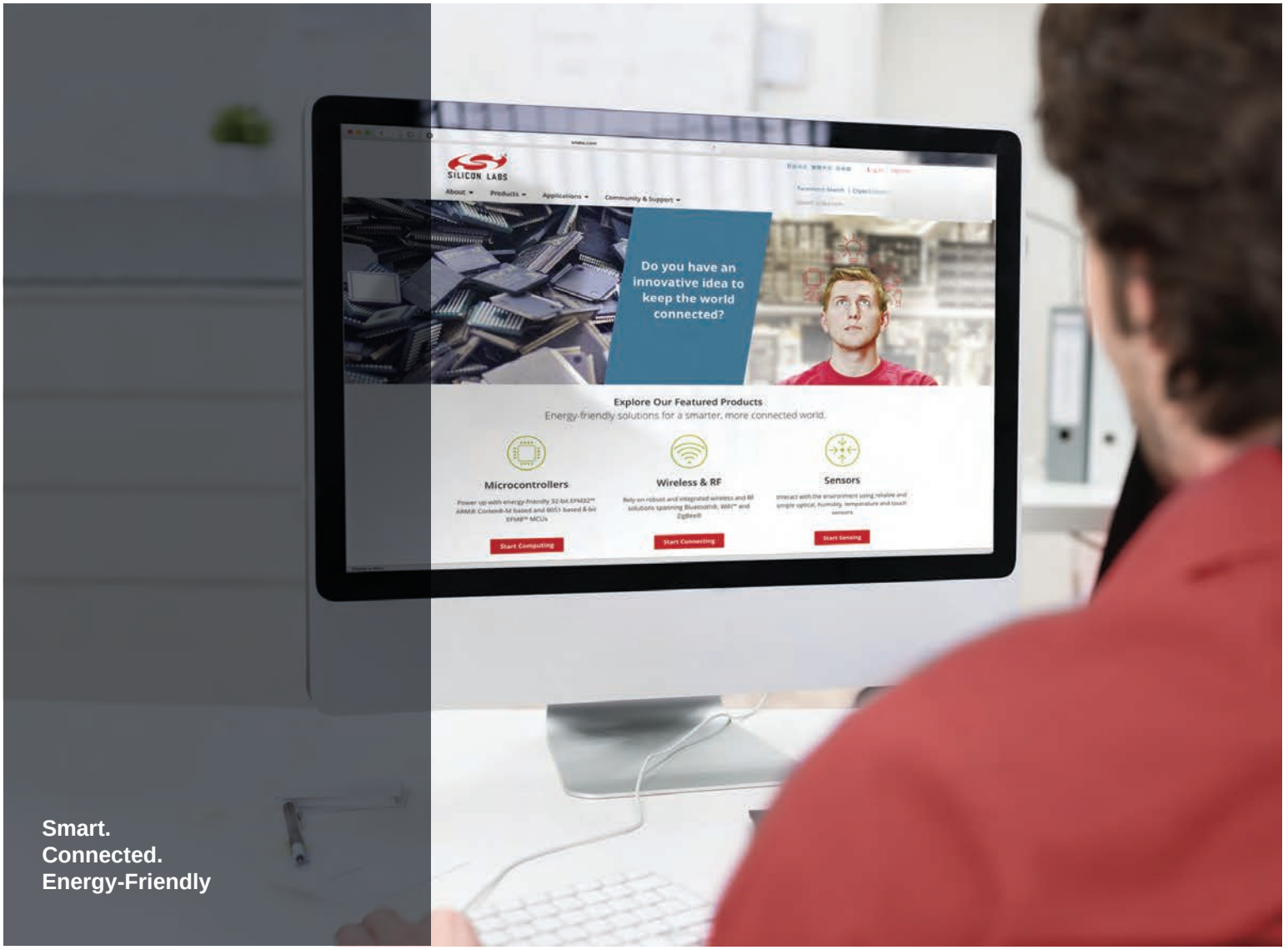


Figure 3. SDA Line at 200 mV per Division

When the 3.3 V side (blue line) goes all the way low, the 1.8 V side (yellow line) goes to about 350 mV, which is the Schottky diode drop. When the 1.8 V side (yellow line) goes all the way low, the 3.3 V side goes to about 150 mV, which is the saturation voltage of the transistor.

4. Conclusion

The low-cost translator circuit allows translation from higher voltages, such as 3.3 or 5 V, to lower voltages, such as 1.8 or 3.3 V. For the case where SCL is unidirectional, only 2 diodes, 3 resistors, and one transistor are needed. In high volume manufacture, the cost of these components would be well under $0.05.



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