Voltage Translation using PI5Cxx Switches

By Paul Li

Introduction

CMOS devices are migrating to 2.5V, 1.8V, 1.5V and 1.2V while interfacing with legacy chipsets working at 5V and 3.3V. This application note will discuss how to use Pericom's PI5Cxx switches for 5V to 3.3V, 5V to 2.5V, and 3.3V to 2.5V voltage translation. Pericom also offers the PI3VTxx product family that also provides a wide range of voltage translation.

Pericom PI5C switches are NMOS switches; the switch cores consist of NMOS transistors, as shown in Figure 1. PI5C switches are suitable for hot-swap applications as well as voltage translation.

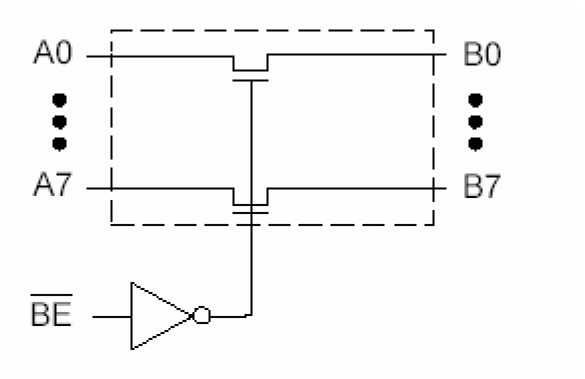

Figure 1: Block diagram of PI5Cxx

The Mechanism of Voltage Translation using NMOS Switch

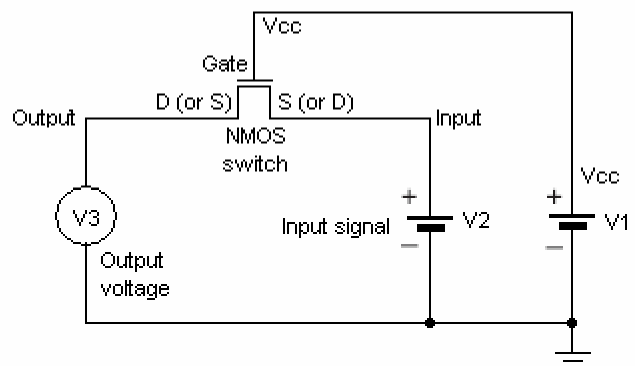

Figure 2: Emulating circuits of PI5Cxx for the relation between the Vcc (V1), input (V2) and output (V3)

The threshold of an NMOS transistor is about 1.0V (varies depending on the process of the NMOS transistor). Hence, a switch will be turned "on" only when Vgs is 1.0V higher than the voltage of the input and output, which is the drain or source of the transistor as shown in Figure 1. Therefore, a PI5Cxx switch will be turned "on" only when:

(V1 - V2) > 1.0V

Thus, at 5V Vcc, the output V3 of the PI5Cxx switch will always be equal to or less than 4.0V. Even though V2 may be higher than 4.0V, the switch will only pass the signal below 4.0V to the output and the input voltage higher than 4.0V will be clamped.

But this output voltage clamp will not draw any current from the input signal. This is an important advantage in voltage translation when using a PI5C switch.

If the Vcc level V1 varies, the output clamping level V_clamp will also vary following V1, as:

V_clamp = V1 – 1.0V

Based on the behavior of PI5C, we can use the switch for voltage translation from 5V to 3.3V, 5V to 2.5V and 3.3V to 2.5V, by varying the Vcc level in order to change the output clamping level.

When:	Vcc = 4.1V	Vcc = 3.5V
Input=5.0V; output =	3.3V	2.5V
Input=3.3V; output =	3.3V	2.5V
Input=2.5V; output =	2.5V	2.5V
Input=1.0V; output =	1.0V	1.0V

Table 1: Relation between the Vcc, input and output

The output voltage in Table 1 may vary depending on the process variation of the PI5C, the input signal frequency, and the output load condition. It is recommended to adjust the Vcc level in a real application for a desirable output voltage level.

Since the drain and source of PI5Cxx switches are not tied to the substrate of the die, the drain and source of the switch is identical, meaning that both sides of the switch can be used as the input or the output for a voltage translation application.

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Vout	R1	R2	Current of R1 and R2
4.1V	90-ohm	410-ohm	10mA
3.5V	150-ohm	350-ohm	10mA

Table 2: Resistance of the voltage divider

Table 2 shows the resistance of the voltage divider in Figure 3 for voltage translation applications using a PI5Cxx switch.

The output voltage Vout of the voltage divider is:

Vout = 5V x R2/(R1+R2)

It is recommended to adjust the proportion of R1 and R2 in a real application until a desirable output level is achieved.

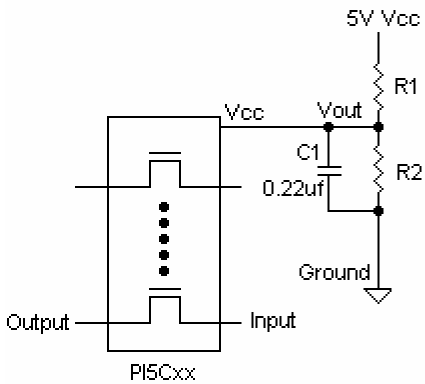

Figure 3: Application circuit of PI5C switch for voltage translation

The circuit in Figure 3 is only for a high-to-low voltage translation. It can not translate a low voltage to a higher level.

The circuit in Figure 4 is shown to translate a 3.3V at side-A to a 5V output at side-B by adding the pull-up resistor R3.

Before using R3, a 3.3V Vcc at side-A will pass through the switch to side-B as a 3.3V output. Adding R3 will pull this 3.3V output at side-B up to the 5V Vcc.

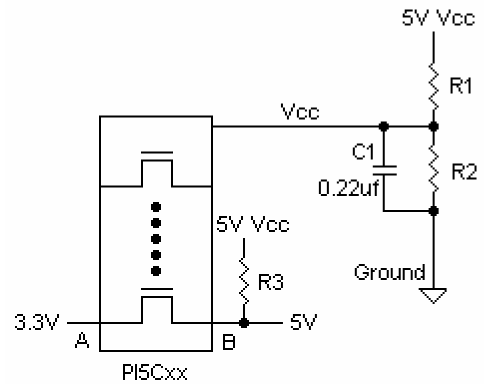

Figure 4: Low-level to high-level voltage translation using the R3

There is a frequency limitation for this low to high voltage translation circuit; it depends on the resistance of R3 and the load at side-B. Normally, if R3 is 1K to 3K, the frequency is limited below 1 MHz, and if R3 is in the range of 200-ohm to 500-ohm, the frequency can be 1 MHz to 5 MHz A trade-off for the higher frequency level is the higher current consumption from R3.

The best way to determine the resistance of R3 in a particular application condition is to simulate the IBIS model of the PI5Cxx switch. These are available on www.pericom.com.

For an input-high signal in the range of 3.0V to 3.3V at side-B, the Vcc of PI5Cxx must be in the range of 3.7V to 3.9V or below, otherwise side B may not be able to pull up to 5V because the high Vcc will turn-on the switch at 3.0V input-high and the 3.0V input-high will then overcome R3 and drag side-B to 3.0V instead of 5V.

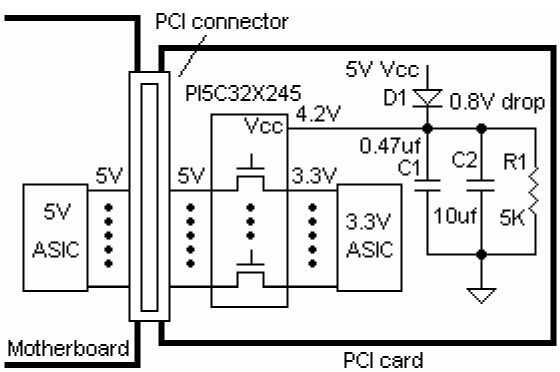

Figure 5: Circuit for the PCI 5V to 3V voltage translation application using the PI5C32X245 switch