ICS ELECTRONICS
division of Systems West Inc.

IEEE 488 APPLICATION BULLETIN

INTERFACING A 4803 TO LOW VOLTAGE LOGIC

INTRODUCTION

Operating voltages for digital systems have dropped from the traditional 5 V to 3.3 V or lower because of the demand for higher speed, lower power consumption and smaller geometry devices. The purpose of this application note is to describe some ways a user can safely interface the 4803's Parallel Interface to low voltage logic devices. This Application Note also applies to ICS's 2303, 2363, 4813, 4823B and 4863 Interface Cards and Modules.

PARALLEL INTERFACE REVIEW

The 4803's Parallel Interface provides 40 I/O data lines that can be configured as inputs or outputs in 8-bit bytes. Physically, the parallel interface is made up of multiple 74ABT543 Octal Registered Transceivers with 33 kohm pullup resistors to 5 V. As inputs, each data line can handle voltages from -0.5 V to +5.5 V. The input switching threshold is 0.8 V to 2.0 V. The maximum input current that the user has to sink is 250 μA at 0.5 V.

When used as outputs, each data line can sink 48 mA at 0.55 V. As outputs, each data line is also capable of sourcing 3 V minimum into a 1000 ohm load (3 mA) and 2 V minimum into a 84 ohm load (24 mA). Because of the driver's greater sink current capability, it is always better to connect any external loads to 5 V and to use the 4803's outputs to sink the load current.

INTERFACING TO LOW VOLTAGE DEVICES

When interfacing between low voltage and high voltage devices, the I_{OH} and I_{OL} currents of the driving device and the V_{IH} and V_{IL} voltages of the receiving device are the most important factors to be considered. Any interface between a low voltage device and a high voltage device can be divided into two different conditions. They are:

Case 1 - When a high voltage device is driving a low voltage device

Case 2 - When a low voltage device is driving a high voltage device.

Each of these cases can be further divided into driving a high signal and driving a low signal.

DRIVING LOW VOLTAGE DEVICES

In this case, the source is the TTL device in the 4803 and the receiver is a low voltage device as shown in Figure 1. This interface can be achieved by five different solutions. They are: using parts that are 5 V input tolerant, using a buffer, using a clamp circuit, using a Zener diode and using a diode clamp circuit.

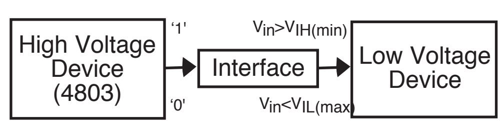

Figure 1 4803 Driving a Low Voltage Device

1) Using 5 V tolerant parts.

This is the best solution since it involves no additional components. When designing your circuit see if the design can be implemented by 5 V tolerant parts. Some low voltage parts are 5 V tolerant on their inputs, some on their outputs and others on both inputs and outputs.

2) Using a buffer

This case is the best solution for new designs where 5 V tolerant parts are not available. Figure 2 shows this case.

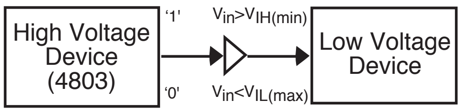

Figure 2 4803 with LVC Buffer

Suggested buffers are Texas Instruments' SN74LVC series parts that handle 5 V inputs or outputs with a 3.3 V Vcc. These series parts are available as Hex Inverters (74LVC14A) for buffering individual lines and as Octal (74LVC245) and 16-bit buffers (74LVC16245) for buffering 8 and 16 lines. Texas Instruments also has parts for buffering lower voltage ICs. Some ACT and HCT parts are also specified to work at 3.3 V.

2) Using a Clamp Circuit

A clamp circuit uses a resistor and a diode to limit the input voltage excursion to the 3.3 V device. Figure 3 shows the Clamp Circuit.

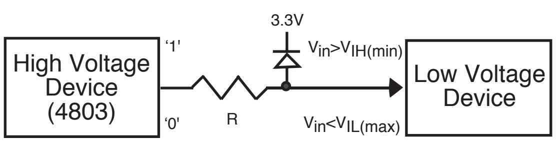

Figure 3 Diode Clamp Circuit

Diode clamps are the best voltage limiters. They have no affect on the signal until it exceeds the forward voltage. The input rating for the low voltage part must be able to withstand 3.3 V plus the diode's forward voltage drop. A low voltage switching diode like a Schottky diode with a 0.3 V forward voltage rating is preferred over a standard silicon switching diode like a 1N916 since it limits the input voltage to 3.6 V.

$$V_{in} = 3.3 + 0.3 \text{ V or } 3.6 \text{ V}$$

Silicon diodes have a V_F of 0.7 volts. Silicon diodes can be used if the low voltage device can tolerate a 4.1 V input. (Some 3.3 V devices have a $V_{in(max)}$ rating of 4.2 V) Set R so the 4803 can pull the low voltage input down to 0.8 V for a logic '0' and still limit the forward current that the diode will see for logic '1' signals. The equation for R is:

$$R = \frac{V_{CC} - V_{diode} - V_{3.3}}{1/2 \times I_{OH(max)}}$$

This equation limits the maximum I_{OH} current to one half of the device rating. Using a diode with V_F = 0.3 V and an I_{OH} of 3 mA, the resistance is computed as 933 ohms. R values down to 466 ohms can be safely used with the 4803 drivers.

3) Using a Zener Diode Clamp

A Zener diode is a simple voltage shunt regulator. It produces a constant voltage by shunting the excess current to ground. As in the diode clamp circuit describe above, the actual voltage drop occurs in the resistor R. Figure 4 shows the Zener Diode Circuit.

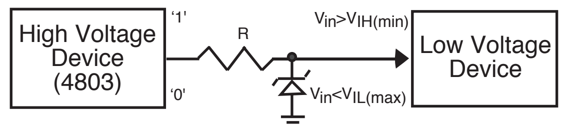

Figure 4 Zener Diode Circuit

Zener diodes have a breakdown curve which starts before the Zener diode rating and becomes fairly flat at the rated voltage and current. Zener diodes are available with breakdown voltages from 3.3 V to 200 V in 5 and 10% tolerance values. The 3.3 V Zener works out well for 3.3 V low voltage devices. Zener diodes start drawing current before they reach their rated voltage and typically draw 3 to 5 mA at their rated voltage. For a 3.3 V Zener, this is more current than the 4803's drivers output for high signals. Therefore, the user will find that the actual high signal input voltage at the low voltage device will be between 2.5 and 3.0 V. The formula for the resistance R is:

$$R = \frac{V_{CC} - V_{Zener}}{1/2 \times I_{OH(max)}}$$

Using 3.3 V for the Zener and 3 mA for I_{OH} results in a resistance value of 1133 ohms. This can be reduced to a low of 566 ohms without damaging the 4803's driver.

Because the lowest Zener voltage is 3.3 V, the Zener diode circuit is not useful for 2.7 V or lower voltage devices.

4) Using the Diode Clamp Circuit

The diode clamp circuit of Figure 5 can be used to block the 4803's 5 V from the low voltage device. The diode clamp circuit works by back biasing the diode when the 4803's high output exceeds the low voltage device's Vcc value.

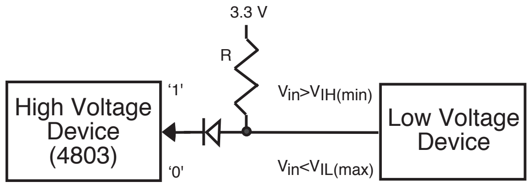

Figure 5 Diode Clamp Circuit

The most important consideration in designing the diode clamp circuit is selecting the resistor value to limit the sink current into the driving device when the device is driving low. A typical load current of 2.5 to 3 mA works for most devices. (Note-Sink current is not a problem for the 4803.) Use a diode with a low V_F to meet the receiving device's V_{IL} limit. Do not use a too large resistor value as large resistance values will slow down the output rise time.

A 1 kohm resistor will limit the sink current to 3.3 mA and will provide good rise times for low to high signal changes. For faster rise times, select a lower resistance value. With a 1 kohm resistor, the 4803's driver output will be about 0.3 V for a low output. Adding 0.3 V for the diodes forward voltage drop makes the receiving device's input about 0.6 V for a low input voltage. The high input value will be limited to the Vcc value that the resistor is connected to.

RECEIVING LOW VOLTAGE SIGNALS

In this case, the source is the low voltage device and the receiver is the 74ABT543 in the 4803 as shown in Figure 5. The $V_{IL(max)}$ value for the 4803 is 0.8 V and the $V_{IH(min)}$ value is 2.0 volts. These values are easily achieved by most 3.3 and 2.7 V low voltage devices. In most cases, the problem becomes how to keep the 4803's 33 kohm pullup resistor to + 5 V from adversely affecting the low voltage device if the low voltage device's outputs are not 5 V tolerant.

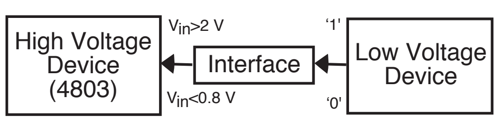

Figure 6 Low Voltage Device driving a 4803

Most of the circuits described above can all be used for the low voltage to 4803 connection. The resistor values will have to be recomputed to be sure they do not exceed the low voltage device's I_{OH} and I_{OL} current limits. The diode clamp circuit does not work in the low voltage to high voltage application.

BIDIRECTIONAL DATA TRANSFER

Bidirectional data transfer although not recommended for the 4803 is sometimes needed in the user's application. In this case, a LVC transceiver like a SN74LVSC245 is a good 5 V to low voltage buffer.

SUMMARY

This application note has described several circuits that can be used to interface a 4803 to low voltage devices. The choice will depend upon the number of lines that have to be interfaced and the low voltage device's tolerance to 5 V. This note applies to all of ICS's GPIB to Parallel Interfaces (Models 2303, 2363, 4803, 4813, 4823B and 4863).