Voltage-Level Adapter Circuit

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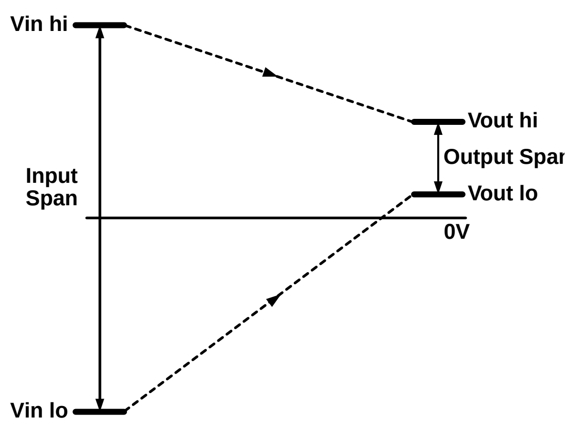
The ispPAC® family of programmable analog circuits is designed to run from a single +5V supply. In most cases, single-supply operation vastly simplifies integrating these parts into mixed-signal systems.

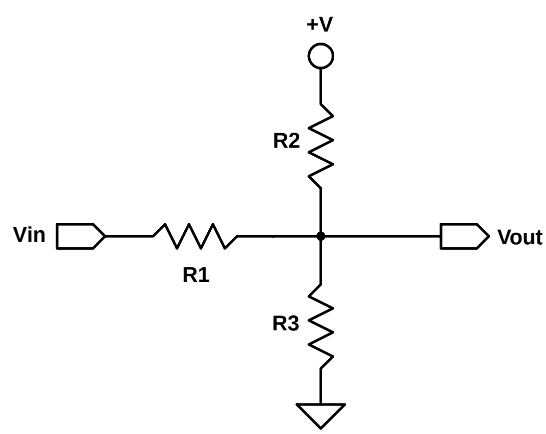
Many real-world signals, such as those generated by sensors, do not always stay within the range of 0-5V. For these signals, higher voltages (15V) and bipolar (+/-) ranges are not uncommon. This can create problems when trying to interface these wide-span signals into modern low-voltage electronic systems. To create an effective interface the large input voltage span needs to be compressed, and possibly offset-shifted to fit into a smaller output span that is compatible with the electronic circuitry's signal range, as is shown in Figure 1.

Figure 1. Compressing an Input Span Into an Output Span



A small amount of simple interface circuitry, however, can be used to level and gain shift large external signals into a range where ispPAC inputs can accommodate them. The three resistor circuit shown in Figure 2 can perform both a scale and offset adjustments simultaneously.

Figure 2. Gain and Offset-Shifting Interface Circuit



The design process for selecting appropriate resistor values is straightforward. To start, one needs to pick a value for R_1. For many applications, values of R_1 from 100kΩ to 10MΩ will be suitable choices. The value of this resistor will strongly influence the circuit's input impedance. The input impedance of the whole network, assuming that the output is used to drive a high-impedance load such as an ispPAC input, can be calculated with Equation 1.

$$R_{in} = R_1 + \frac{R_2 R_3}{R_2 + R_3} \qquad (1)$$

Next, one uses Equations 2 and 3 to calculate the respective values of R_2 and R_3 from the voltage levels of the input and output spans (Vin_{HI}, Vin_{LO}, $Vout_{HI}$, $Vout_{LO}$), R1, and the bias voltage V+ (typically 5V).

$$R_2 = R_1\left[\frac{V^+ \cdot (Vout_{LO} - Vout_{HI})}{Vout_{HI} \cdot Vin_{LO} - Vout_{LO} \cdot Vin_{HI}}\right] \qquad (2)$$

$$R_3 = R_1\left[\frac{V^+ \cdot (Vout_{LO} - Vout_{HI})}{Vin_{LO} \cdot V^+ - Vout_{LO} \cdot V^+ + Vout_{HI} \cdot V^+ - Vin_{HI} \cdot V^+ + Vout_{LO} \cdot Vin_{HI} - Vout_{HI} \cdot Vin_{LO}}\right] \qquad (3)$$

As an example, let's consider an interface to convert from a +/-10V span to the +1 to +4V span optimal for an ispPAC10 input. For this example, let V+=5V, and R_1 = 1 Meg Ω. The span variables are:

Vin_{HI} = +10V Vin_{LO} = -10V

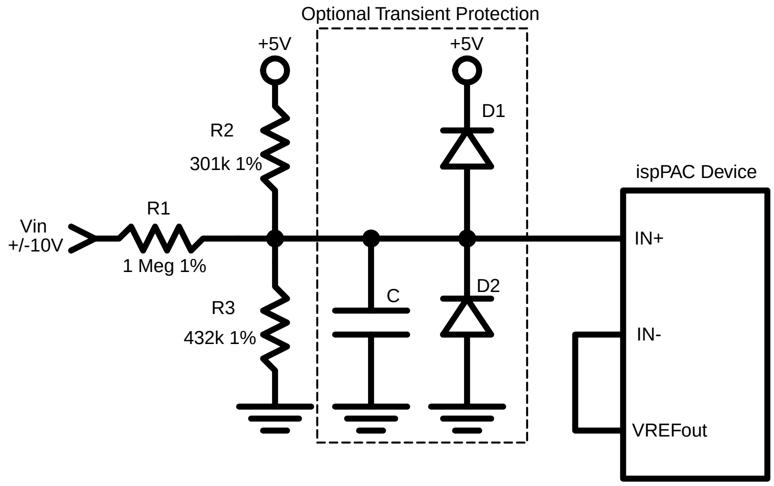
$Vout_{HI}$ = +4V $Vout_{LO}$ =1V

This results in R_2 = 300kΩ, and R_3= 428kΩ. Since standard resistors only come in fixed values, a good choice of stock 1% resistor values for this application might be to use 302kΩ for R_2 and 432kΩ for R_3. For these particular choices of resistor values, a +/-10V input span will compress down to an output range of 0.989 to 4.008 V, for nominal resistor values.

While this method of input scaling can accommodate many situations, there will be some span adjustments beyond its capabilities. In these cases, the design equations will indicate an unrealizable design with zero, infinite, or negative resistor values. One obvious case is where a small input span must be mapped onto a larger output span. In this case active amplification is required and the passive network presented here will not work.

If the circuit is to be used as an input buffer for signals coming in from the outside world, such as those being input to a system through a connector, it may also be desirable to add some filtering, ESD, and transient protection. Figure 3 shows an example of a simple ESD protection network implemented by adding two diodes and a capacitor. Because of the variety of operating environments in which electronic systems are used, there is no universal solution to the problem of input protection. Both the type of input protection circuitry and the components chosen to implement it will be heavily dependent on both the application in which the circuit is used and the conditions under which it will be operated.

Figure 3. Example of +/-10V Interface with Transient Protection



Technical Support Assistance

Hotline: 1-800-LATTICE (Domestic)
1-408-826-6002 (International)
e-mail: ispPACs@latticesemi.com