

With the resistors determined, the next step is to calculate the required reference voltage to achieve the desired thresholds. Using the slightly simpler expression for V_{TLH} provides the following result:

$$V_{TLH} = 1.8 = V_{REF} \frac{R1 + R2}{R2} = V_{REF}(1.12), V_{REF} = 1.61 \text{ V}$$

Because 1.61 V is not a particularly standard voltage, it can be obtained using a voltage divider resistor network. The math can be checked by verifying that the selected values for V_{REF} , $R1$, and $R2$ also produce the desired V_{THL} .

$$V_{THL} = V_{REF} \frac{R1 + R2}{R2} - 5 \frac{R1}{R2} = 1.61(1.12) - 5(0.12) = 1.2 \text{ V}$$

Certain digital interface applications benefit from off-the-shelf 7400 logic gates with built-in hysteresis. A common industry term for a circuit employing hysteresis is the *Schmitt trigger*. Devices employing Schmitt triggers include the 74xx14 hex inverter and the 74xx132 quad NAND. The graphical symbol used to denote Schmitt trigger logic inputs is the hysteresis loop placed within a standard logic gate representation, two examples of which are shown in Fig. 14.33. The 74LS14 and 74LS132 Schmitt trigger devices are members of the common 74LS bipolar logic family. Each of these devices is specified with $1.4 = V_{TLH} = 1.9$ and $0.5 = V_{THL} = 1.0$.^{*} These specifications guarantee a minimum hysteresis of 0.4 V, making them suitable for handling many noisy signals.

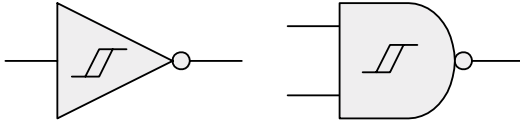


FIGURE 14.33 Graphical representation of Schmitt trigger inverter and NAND gate.

^{*} 74LS14, Fairchild Semiconductor Corporation, 2000, p. 2.

CHAPTER 15

Analog Interfaces for Digital Systems

The intersection of analog and digital worlds has given rise to a tremendously broad range of applications for digital systems. Digital cellular telephones, enhanced radar systems, and computerized engine controls are just a few modern benefits enabled by data conversion circuits. Analog-to-digital and digital-to-analog converters enable computers to interact with the real world by representing continuous analog signals as sequences of discrete numbers.

The first portion of this chapter discusses topics including quantization, sampling rate, and the Nyquist frequency. These concepts form the foundation of data conversion and enable an engineer to evaluate the conversion requirements for individual applications. Specific analog-to-digital and digital-to-analog conversion techniques are presented in the next portion of the chapter. Selecting the correct data conversion IC is a combination of identifying the application requirements and then finding a device that matches these specifications.

Following the initial evaluation process, designing an effective data conversion circuit at the system level varies in complexity with how accurate the conversion must be. Some applications with moderate accuracy requirements can be implemented without much difficulty by following the manufacturer's recommended connection diagrams in their data sheets and application notes. More complex conversion circuits, such as those in digital radio transceivers or high-accuracy instruments, can present significant analog design tasks wherein noise reduction and stability over time and temperature are key challenges. While briefly discussed at the end of this chapter, these high-end applications require further reading into sampling theory and more advanced analog design skills.

15.1 CONVERSION BETWEEN ANALOG AND DIGITAL DOMAINS

Many digital systems interact with their environment by measuring incoming analog signals, such as sound from a microphone, and emitting other analog signals that have been processed in some manner, such as playing a CD on your computer's speakers. These functions are not natural to digital systems, because a binary signal can have only two discrete states, 1 and 0, whereas analog signals are continuous and exist at a wide range of voltages. Specific circuits and methods are necessary to convert between the two domains of discrete digital signals and continuous analog signals.

Analog-to-digital converters (ADCs) and *digital-to-analog converters* (DACs) bridge the gap between our decidedly analog world and the digital world of microprocessors and logic. Essentially, an ADC takes an instantaneous snapshot, or *sample*, of an analog input and converts the observed voltage into a string of binary digits—a number. A DAC performs the reverse operation of converting a discrete number into an analog output voltage. Let's first examine a conceptual ADC.