

# **Reduce Noise and Save Power with the New HCS Logic Family**

*Dylan Hubbard*

### **ABSTRACT**

System designers are continuously striving to improve signal integrity, reduce power, and increase robustness in Automotive, Industrial, Personal Electronics, and other electronic systems. The Texas Instruments™ (TI) next-generation Schmitt-trigger Integrated High-speed CMOS family was designed to achieve these goals. This 2 to 6-V Logic family was developed to improve digital signal integrity in systems that are affected by noise inherent to the environment it is in. The integration of Schmitt-triggers to all inputs eliminates a majority of the issues seen with logic devices that stem from normal CMOS inputs. HCS accomplishes all this while maintaining a low power consumption.

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## 1 Introduction

The High-speed CMOS, or HC, family of Logic devices has been the benchmark for 5-V CMOS system design for nearly 4 decades. It is still being used in millions of different products today and will continue to be for decades to come. It was designed with a solid architecture allowing it to be higher-speed and lower-power compared to the technology that came before. It also utilizes a balanced output with lower drive to avoid any issues with undershoot or overshoot. Because of this, the HC family was used as a foundation for TI's new, next-generation logic family designed with new process technology. The end result is the Schmitt-trigger Integrated High-Speed CMOS, or HCS, family.

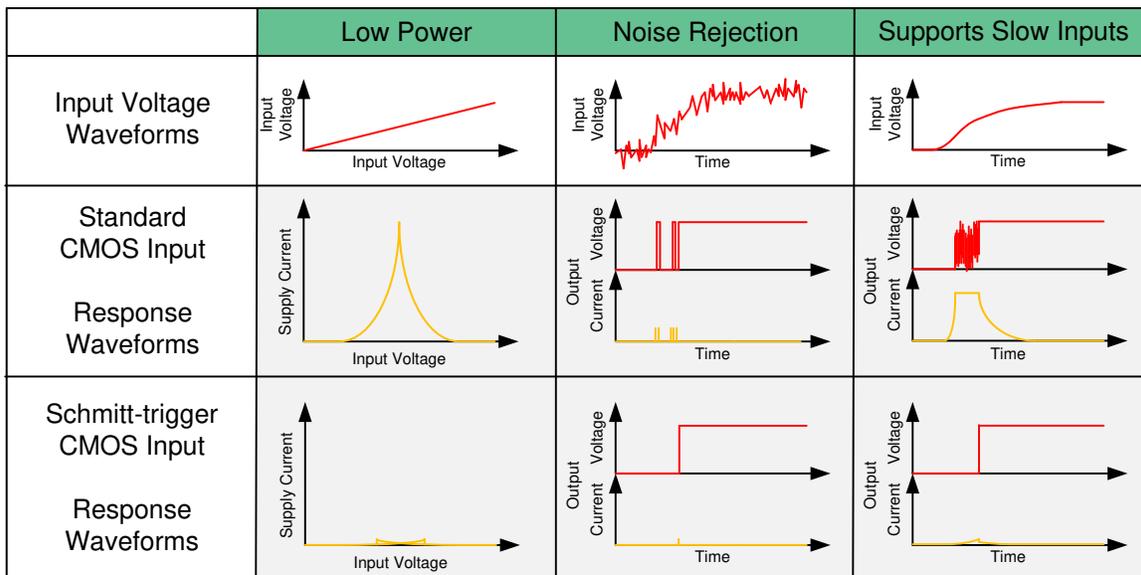
The wide operating supply voltage range coupled with each device having a commercial and automotive version, makes the HCS family a very versatile solution for discrete logic. Not all new designs are created from the ground up, but instead are built off previous design revisions. The pin-to-pin compatibility between HC and HCS will make it easier for the designer to replace an HC device used on a previous revision without having to redesign the layout.

## 2 Input/Output Characteristics

### 2.1 Schmitt-Trigger Inputs

TI developed the HCS family to improve performance and robustness over older technology. The best way to do this is to eliminate very common issues encountered with normal CMOS inputs such as oscillations from slow or noisy inputs and excessive power consumption due to slow inputs, refer to [Implications of Slow or Floating CMOS Inputs](#). With the integration of Schmitt-triggers on all inputs, these issues are avoided.

Schmitt-triggers provide benefits to power consumption and noise rejection on digital signals while not limiting the speed at which the input signal transitions.



**Figure 1. Benefits of Schmitt-trigger Inputs in the HCS Logic Family**

Figure 1 illustrates the three benefits Schmitt-triggers provide with example input signals and the resulting output waveforms. To learn more about the operation of Schmitt-triggers, please refer to the [Understanding Schmitt Triggers](#) application report and the [Eliminate Slow or Noisy Input Signals](#) Logic Minute Video.

## 2.2 Balanced Outputs

The HCS family provides balanced outputs capable of driving up to  $\pm 7.8$  mA while maintaining a valid logic level. Figure 2, Figure 3, Figure 4, and Figure 5 illustrate the typical output characteristics of the HCS family.

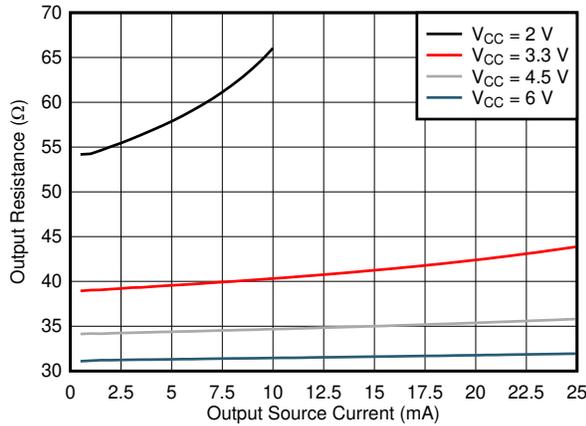


Figure 2. Output driver resistance in High state

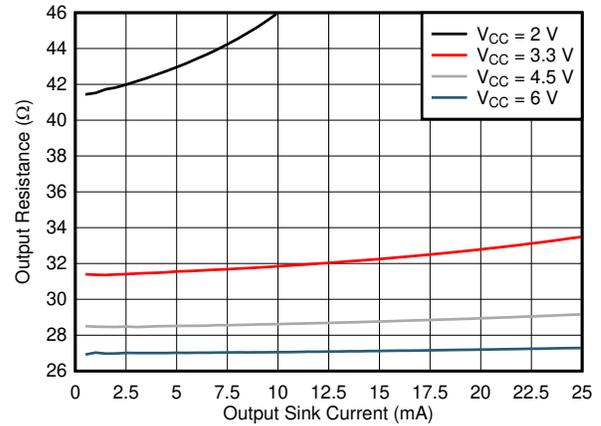


Figure 3. Output driver resistance in LOW state

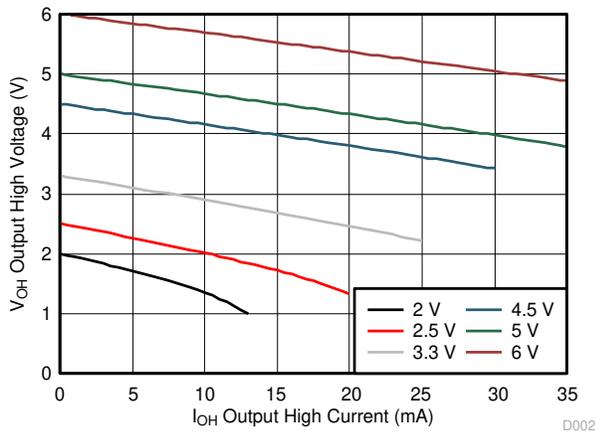


Figure 4. Typical output high voltage versus source current across common supply values

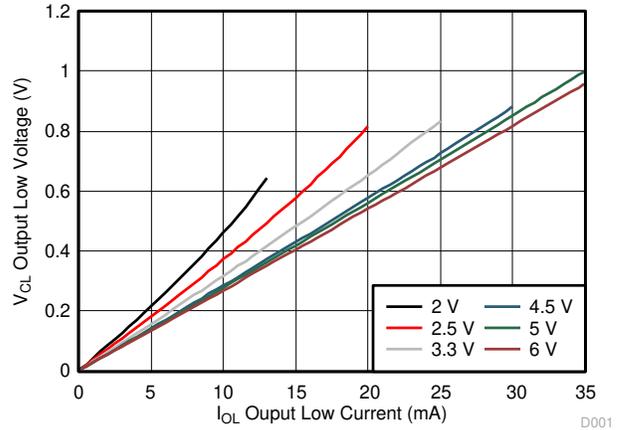


Figure 5. Typical output low voltage versus sink current across common supply values

### 3 Power Consumption

The HCS family utilizes new process technology to achieve a low power consumption. It has a maximum  $I_{CC}$  of 2  $\mu A$ , making it the lowest compared to other popular 5-V logic families. The dynamic power consumption also stacks up well to the other popular 5-V families with a  $C_{pd}$  of only 10 pF. For more information on CMOS power consumption and how to calculate total power consumption, please refer to the [CMOS Power Consumption and  \$C\_{pd}\$  Calculation](#) application report.

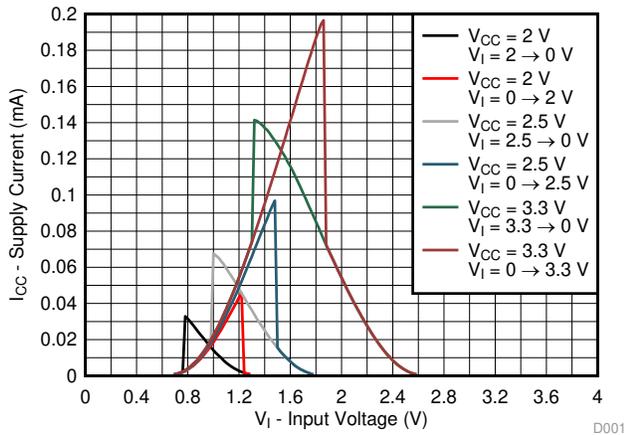


Figure 6. Typical supply current versus input voltage across common supply values (2 V to 3.3 V)

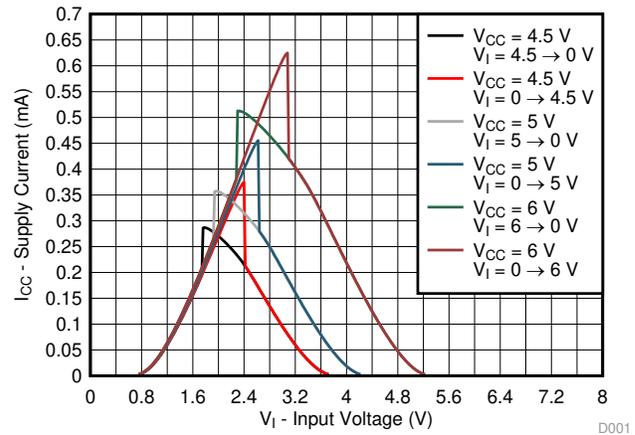


Figure 7. Typical supply current versus input voltage across common supply values (4.5 V to 6 V)

### 4 Common Logic Applications with Less Power and More Noise Rejection

#### 4.1 ANDing Reset Signals for Motor Control

Schmitt-trigger inputs broaden the possible applications the logic devices in the HCS family. For example, in Automotive powertrain or Industrial PLC applications, it is expected for the digital signals to be exposed to a noisy environment. Large transient voltage spikes and other devices with harsh switching components can cause an abundance of noise to show up on the digital signals in the system. This can be detrimental to a system if erroneous data shows up for a logic reset control. The use case in [Figure 8](#) illustrates how the [SN74HCS08-Q1](#) device becomes the perfect solution for a motor control reset in an Automotive Body system.

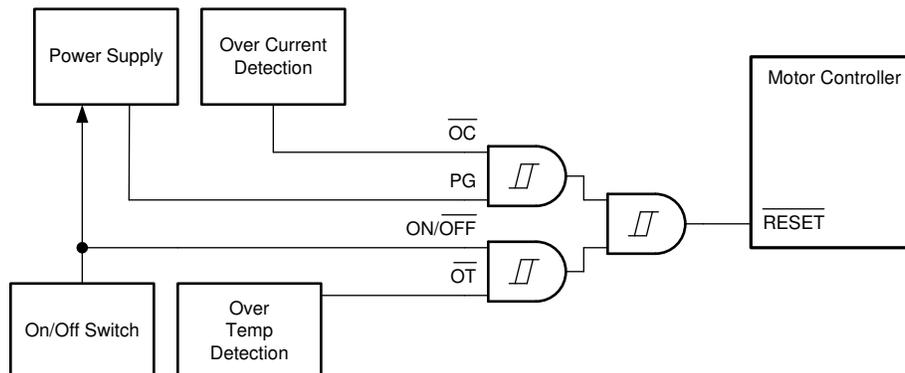
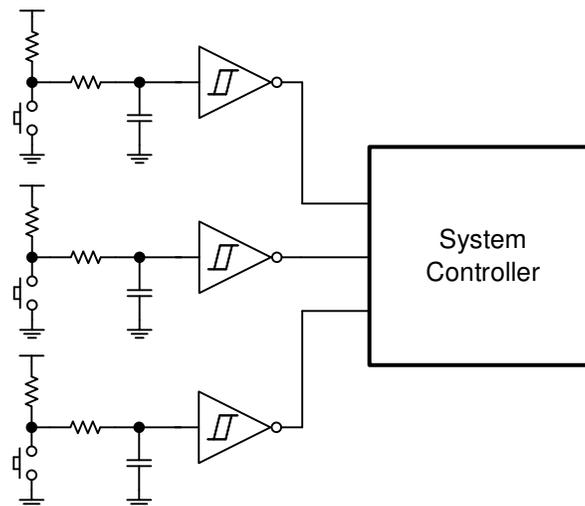


Figure 8. Motor controller reset logic control using SN74HCS08-Q1

The [SN74HCS08-Q1](#) will be able to reject the noise coupled to the input signal up to the minimum hysteresis spec, or  $\Delta V_T$ . If the noise is expected to be greater than the minimum hysteresis spec, then additional filtering can be applied to any input of this AND gate with no issue from the inherently slow transition rate of the filtered signal. This also applies to signals that have to travel far distance over wire or traces as these signals will be affected by parasitic capacitances causing them to have a slower transition rate. If this logic control is being supplied with standby power, then the low power consumption of the HCS family will save on the power budget given for devices loading the car battery.

#### 4.2 Button Debounce for Multiple Push-buttons

Personal electronic systems can also capitalize on the low power consumption of the HCS family. If a wireless speaker powered from a lithium battery has multiple push button controls, then the [SN74HCS04](#) use case illustrated in [Figure 9](#) is a perfect solution to easily debounce the button without additional software effort.



**Figure 9. Multiple push-button debounce using SN74HCS04**

Power efficiency is critical for these systems as to not rapidly drain the battery. The Schmitt-trigger power savings and the great dynamic power performance incorporated into the HCS family, will allow for users to play and pause music or turn the volume up without wasting battery life.

### 4.3 Momentary to Toggle Switch with Power-on Reset

HCS logic devices not only provide more noise immunity and lower power operation to a variety of applications, but they can also turn common applications into more size efficient and lower cost solutions. An example application would be turning a momentary switch into a toggle switch using a D-type flip-flop.

Toggle switches are typically large, mechanically complex and relatively expensive. It is desirable to use a momentary switch instead because they are small, mechanically simple and low cost. Some systems require a toggle switch's functionality but are space or cost constrained and must use a momentary switch instead. The [SN74HCS74-Q1](#) has integrated Schmitt-trigger inputs that eliminate the need for a second IC for signal conditioning, reducing the required board space and eliminating the added cost. This makes the [SN74HCS74-Q1](#) an ideal device for converting a momentary switch into a toggle switch compared to a D-type flip-flop in another family. [Figure 10](#) shows the application diagram of a D-type flip-flop being used without integrated Schmitt-triggers versus [Figure 11](#) which shows the same application using the [SN74HCS74-Q1](#).

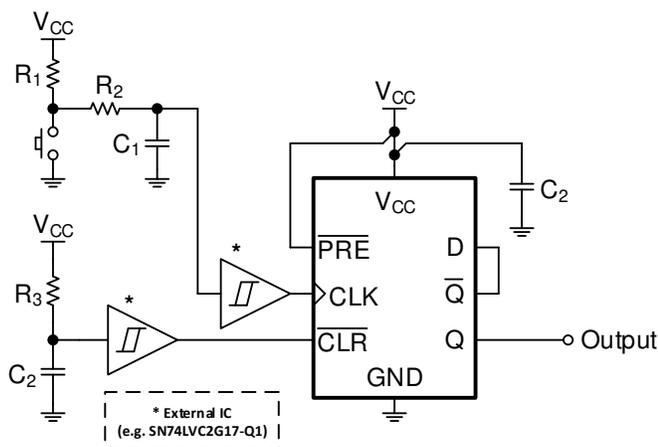


Figure 10. Toggle Switch w/o Integrated Schmitt-triggers

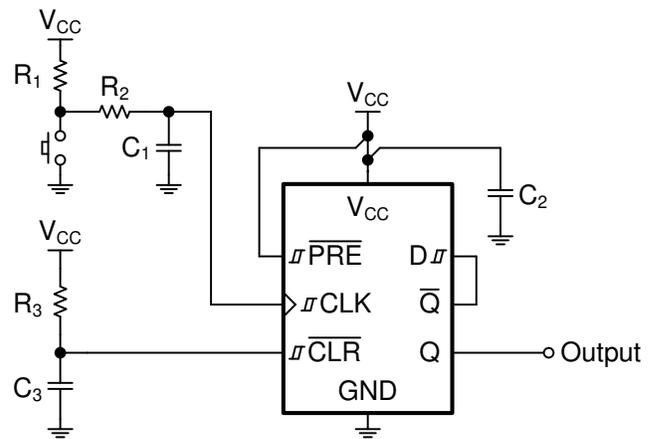


Figure 11. Toggle Switch w/ Integrated Schmitt-triggers

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