Application Brief

Interpolating Specification Values for TI Logic Families

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Why do we need to use linear interpolation?

Some logic families, such as the HC and HCS families, specify parameters only at supply voltages of 2V, 4.5V, and 6V. As most systems operate logic devices at 1.8V, 3.3V, or 5V supply voltages, designers working with these or similar families often need to use linear interpolation to determine various performance specifications at the appropriate supply voltage. Linear interpolation of data sheet tables can be used to determine minimum and maximum performance specifications specified by the datasheet. Linear interpolation can also be used to estimate typical performance values at any V_{CC} voltage within the minimum and maximum V_{CC} range provided by the recommended operating conditions.

Example Calculation

Let's determine the minimum V_{IH} and maximum V_{IL} values of the SN74HC595 at 3.3V V_{CC}. V_{IH} and V_{IL} are provided in the *Recommended Operation Conditions* table of the datasheet, which is provided in SN74HC595 Recommended Operating Conditions.

SN74HC595 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)(1)

			SN54HC595			SN74HC595			UNIT
			MIN	NOM	MAX	MIN	NOM	MAX	
V_{CC}	Supply voltage		2	5	6	2	5	6	V
V_{IH}	High-level input voltage	V_{CC} = 2V	1.5			1.5			V
		V_{CC} = 4.5V	3.15			3.15			
		V_{CC} = 6V	4.2			4.2			
V_{IL}	Low-level input voltage	V_{CC} = 2V			0.5			0.5	V
		V_{CC} = 4.5V			1.35			1.35	
		V_{CC} = 6V			1.8			1.8	
V_I	Input voltage		0		V_{CC}	0		V_{CC}	V
V_O	Output voltage		0		V_{CC}	0		V_{CC}	V
Δt/Δv	Input transition rise or fall time(2)	V_{CC} = 2V			1000			1000	ns
		V_{CC} = 4.5V			500			500	
		V_{CC} = 6V			400			400	
T_A	Operating free-air temperature		–55		125	–40		85	°C

(1) All unused inputs of the device must be held at V_{CC} or GND to verify proper device operation. See the TI application report, *Implications of Slow or Floating CMOS Inputs*, SCBA004.

(2) If this device is used in the threshold region (from V_{IL}max = 0.5V to V_{IH} min = 1.5V), there is a potential to go into the wrong state from induced grounding, causing double clocking. Operating with the inputs at t_t = 1000ns and V_{CC} = 2V does not damage the device; however, functionally, the CLK inputs are not verified while in the shift, count, or toggle operating modes.

The minimum V_{IH} is given as 1.5V at V_{CC} = 2V and 3.15V at V_{CC} = 4.5V. For the minimum V_{IH} at 3.3V V_{CC}, we can interpolate between these two data points as follows:

$$V_{\mathrm{IH}}\,(\mathrm{VCC} = 3.3\ \mathrm{V}) \ = 1.5 + (3.3 - 2) \times \frac{3.15 - 1.5}{4.5 - 2} = 1.5 + (3.3 - 2) \times \frac{1.65}{2.5} = 2.358\ \mathrm{V}.$$

Similarly, the maximum V_{IL} is given as 0.5V at V_{CC} = 2V and 1.35V at V_{CC} = 4.5V. For the maximum V_{IL} at 3.3V V_{CC}, we calculate: $V_{\mathrm{IL}}\,(\mathrm{VCC} = 3.3\ \mathrm{V}) \ = 0.5 + (3.3 - 2) \times \frac{1.35 - 0.5}{4.5 - 2} = 0.5 + (3.3 - 2) \times \frac{0.85}{2.5} = 0.942\ \mathrm{V}.$

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