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APPLICATION NOTE

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HC05 MCU LED Drive Techniques Using the MC68HC705J1A

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INTRODUCTION

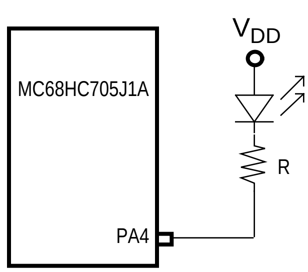
This application note demonstrates how the high-current sink pins of an MC68HC705J1A drive a light-emitting diode (LED) directly without requiring an external amplifying transistor.

The math used to determine the current-limiting resistor value is valid for any HC05 MCU port pin regardless of the pin's output low current (I_{OL}) rating. Only the maximum I_{OL} specification need be changed in the equations.

BACKGROUND

Normal HCMOS I/O pins have sufficient current to drive a reasonable fan-out of HCMOS or TTL inputs. These pins are commonly specified to sink 1.6 mA with an output low voltage of 0.4 V. However, in cases when an HCMOS output is used to drive a device requiring significantly more current, these port pins are not sufficient. Examples include an LED, optoisolator and the first stage of an amplifier, each of which often require up to 10 mA.

The MC68HC705J1A has four input/output (I/O) pins (ports A4-A7) that are rated to sink 10 mA with a output low voltage (V_{OL}) of 0.4 V, which easily can accommodate drive requirements of LEDs and other devices. An example LED drive schematic is shown below.



DETERMINING RESISTOR VALUE

To find a first approximation for R, use Ohms Law and divide the power supply voltage by the current to be sunk:

$$R = \frac{V_{DD}}{I_{OL}}$$

Using a V_{DD} of 5 V and a I_{OL} of 10 mA, the result is a 500-Ω resistor. Although this is a simplistic approach, by using it the 10 mA specification will not be exceeded. Due to other voltage drops, (the LED forward voltage and the port V_{OL}), the actual voltage across the resistor will be much less. Consequently, the current will be much less.

Taking those drops into account:

$$R = \frac{V_{DD} — V_{f,LED} — V_{OL}}{I_{OL}}$$

The effect of varying values must be considered also. To remain at 10 mA or less, use the extreme value that will cause the most current to be drawn, and the equation becomes:

$$R_{MIN} = \frac{V_{DD,MAX} — V_{f,LED,MIN} — V_{OL,MIN}}{I_{OL,MAX}}$$

This equation gives the minimum resistor value, R_{MIN}. Resistors are rated by tolerance:

$$R_{MIN} = R — tol \times R$$

$$R = \frac{R_{MIN}}{1 — tol}$$

R_{MIN} can now be substituted to arrive at:

$$R = \frac{V_{DD,MAX} — V_{f,LED,MIN} — V_{OL,MIN}}{(1 — tol) \times I_{OL,MAX}}$$

Where:

1)	R	Resistor Center Value
2)	$V_{DD,MAX}$	Maximum Power Supply Voltage
3)	$V_{f,LED,MIN}$	Minimum LED Forward Voltage at $I_{OL,MAX}$
4)	$V_{OL,MIN}$	Minimum Output Low Voltage from MCU at $I_{OL,MAX}$
5)	tol	Tolerance of Resistor — .05, .10, or .20
6)	$I_{OL,MAX}$	Maximum Current to be Allowed

Most of these can be read from a data sheet. However, $V_{OL,MIN}$ is not known. The part specification uses 0.4 V for $V_{OL,MAX}$. Since minimum is needed for the worst-case current sink, the safest number to use is 0 V, although measurement will show a value closer to 0.1 V.

5 Volt Resistor Value

For V_{DD} = 5 V 10%, $V_{LED,MIN}$ = 1.8 V, $V_{OL,MIN}$ = 0 V, tol = 5%, $I_{OL,MAX}$ = 10 mA

The nominal R value is 389 . The next larger value commonly available is 390 .

3.3 Volt Resistor Value

For V_{DD} = 3.3 V 10%, $V_{LED,MIN}$ = 1.8 V, $V_{OL,MIN}$ = 0 V, tol = 5%, $I_{OL,MAX}$ = 5 mA

The nominal R value is 385 . The next larger value commonly available is 390 .

CONCLUSION

A much smaller resistor — and, therefore, a brighter LED — than the first approximation can be used while maintaining assurance that $I_{OL,MAX}$ specifications will not be violated.

Also, the equations given here are valid for any port pin. Simply use the appropriate values for $I_{OL,MAX}$ and $V_{OL,MIN}$. Although a normal port pin would be able to sink less current, the design rules hold true.

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