

# HC05 MCU LED Drive Techniques Using the MC68HC705J1A

By David Yoder  
CSIC Applications

## INTRODUCTION

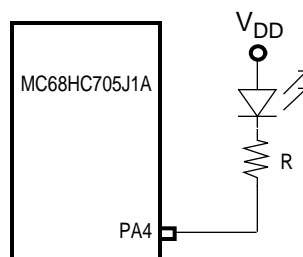
This application note demonstrates how the high-current sink pins of an MC68HC705J1A drive a light-emitting diode (LED) directly without requiring an external amplifying transistor.

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- $\Omega$  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%,  $V_{f,LED,MIN} = 1.8$  V,  $V_{OL,MIN} = 0$  V, tol = 5%,  $I_{OL,MAX} = 10$  mA

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

### 3.3 Volt Resistor Value

For  $V_{DD} = 3.3\text{ V}$  10%,  $V_{LED,MIN} = 1.8\text{ V}$ ,  $V_{OL,MIN} = 0\text{ V}$ ,  $\text{tol} = 5\%$ ,  $I_{OL,MAX} = 5\text{ mA}$   
 The nominal R value is 385  $\Omega$ . The next larger value commonly available is 390  $\Omega$ .

## 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.

## How to Reach Us:

### Home Page:

[www.freescale.com](http://www.freescale.com)

### E-mail:

[support@freescale.com](mailto:support@freescale.com)

### USA/Europe or Locations Not Listed:

Freescal Semiconductor  
Technical Information Center, CH370  
1300 N. Alma School Road  
Chandler, Arizona 85224  
+1-800-521-6274 or +1-480-768-2130  
[support@freescale.com](mailto:support@freescale.com)

### Europe, Middle East, and Africa:

Freescal Halbleiter Deutschland GmbH  
Technical Information Center  
Schatzbogen 7  
81829 Muenchen, Germany  
+44 1296 380 456 (English)  
+46 8 52200080 (English)  
+49 89 92103 559 (German)  
+33 1 69 35 48 48 (French)  
[support@freescale.com](mailto:support@freescale.com)

### Japan:

Freescal Semiconductor Japan Ltd.  
Headquarters  
ARCO Tower 15F  
1-8-1, Shimo-Meguro, Meguro-ku,  
Tokyo 153-0064  
Japan  
0120 191014 or +81 3 5437 9125  
[support.japan@freescale.com](mailto:support.japan@freescale.com)

### Asia/Pacific:

Freescal Semiconductor Hong Kong Ltd.  
Technical Information Center  
2 Dai King Street  
Tai Po Industrial Estate  
Tai Po, N.T., Hong Kong  
+800 2666 8080  
[support.asia@freescale.com](mailto:support.asia@freescale.com)

### For Literature Requests Only:

Freescal Semiconductor Literature Distribution Center  
P.O. Box 5405  
Denver, Colorado 80217  
1-800-441-2447 or 303-675-2140  
Fax: 303-675-2150  
[LDCForFreescaleSemiconductor@hibbertgroup.com](mailto:LDCForFreescaleSemiconductor@hibbertgroup.com)

Information in this document is provided solely to enable system and software implementers to use Freescal Semiconductor products. There are no express or implied copyright licenses granted hereunder to design or fabricate any integrated circuits or integrated circuits based on the information in this document.

Freescal Semiconductor reserves the right to make changes without further notice to any products herein. Freescal Semiconductor makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does Freescal Semiconductor assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation consequential or incidental damages. "Typical" parameters which may be provided in Freescal Semiconductor data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals" must be validated for each customer application by customer's technical experts. Freescal Semiconductor does not convey any license under its patent rights nor the rights of others. Freescal Semiconductor products are not designed, intended, or authorized for use as components in systems intended for surgical implant into the body, or other applications intended to support or sustain life, or for any other application in which the failure of the Freescal Semiconductor product could create a situation where personal injury or death may occur. Should Buyer purchase or use Freescal Semiconductor products for any such unintended or unauthorized application, Buyer shall indemnify and hold Freescal Semiconductor and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that Freescal Semiconductor was negligent regarding the design or manufacture of the part.

