Mosaic Industries

MC58HC11 Output Port Drive Capability

APPLICATION NOTE
MI-AN-060

Summary

The following describes the MC68HC11 output port drive capability.

Description

On the QED-3 Board the processor's ports A and D are available for you to connect to external devices. You can use them to directly drive LEDs, relays, transistors, opto-isolators or other digital logic devices. But please be careful -- whenever these outputs are connected to external devices you must stay within the voltage and current capabilities of the output pins. Because the MC68HC11 reference manuals don't specify the electrical capability of these ports very well we provide some additional information here.

These output pins are very useful because they can directly drive a wide range of devices. Nevertheless, any circuitry connected to the processor should take care to:

1) Prevent excessive voltage levels at the pin; and,
2) Prevent excessively great currents.

Preventing Excessive Voltages

Excessive voltages are prevented by ensuring that voltages of less than a diode drop below V_{SS} (-0.6 V) or greater than a diode drop above V_{DD} (V_{DD}+0.6 V) are never applied to the processor. For some applications, particularly when driving inductive loads such as relays, you may need to provide Schottkey diode clamps between the pin and V_{DD} and between the pin and ground. All pins on the processor have inherent diode clamps to the processor's ground voltage, V_{SS}, but it is best not to rely on these; if there is the possibility of the output pin being driven to a negative voltage level it is better to prevent excessive power dissipation in the processor package by externally clamping the voltage to ground (V_{SS}) with a Schottkey diode. Processor ports A and D also have inherent diode clamps to the chip's supply voltage, V_{DD}, but it is likewise better not to rely on these; instead external Schottkey clamps to V_{DD} should be used.

Preventing Excessive Currents

The current into or out of any pin on the MC68HC11 should also be limited to prevent damage. The specified *maximum* current is 25 mA into or out of any one pin at a time, although these pins can typically withstand transients of more than 100 mA at room temperature. In driving more than one pin at a time it is necessary only to stay within the processor's maximum power dissipation. Unfortunately, *Motorola* doesn't specify what this maximum is, but *we* recommend that you don't exceed a total of 100 mW for all processor I/O pins combined. The chip's total power dissipation is the sum of its internal power (which varies from device to device so much that it can only be determined by actually measuring it, but which is specified at less than 150 mW) and the power associated with the I/O pins. Pin currents must be limited using external resistors.

Output Pin V-I Characteristics

The output pins of the MC68HC11 microcontroller are similar in electrical characteristics to the SN54/74HC digital logic family. They are capable of sourcing or sinking up to 25 mA per output. They are *guaranteed* to source up to 0.8 mA while providing a valid logic high and to sink up to 1.6 mA at a valid logic low, although they generally do much better as shown in the following figures. A valid logic high level is between $V_{OH} = V_{DD}$ and $V_{OH} = V_{DD}$ - 0.8 V, and a valid low level is between $V_{OL} = V_{SS}$ = 0 V and $V_{OL} = V_{SS}$ + 0.4 V. As the output sources or sinks current, the V_{OL} and V_{OH} levels rise or fall respectively. It is often useful to know just how much to expect the V_{OL} and V_{OH} levels to vary with current. For currents of less than 10 mA the voltage change is linear with current; that is, the output can be modeled as a voltage source of either zero or five volts and an equivalent series resistor of about 40 ohms. At greater output currents the equivalent series resistance increases. The following figures (Figure 1 and Figure 2) illustrate this variation.

These figures can be used when choosing component values for particular drive circuits. For example, the following figure shows a pin of Port A or D driving a light-emitting diode. The resistor functions as a current limiter. The luminous intensity of the LED depends on the amount of forward current. Its forward voltage at a current of 10 mA is 2.2 V. For the first figure, in which the LED is driven by a output high, the value of the current limiting resistor can be calculated as:

$$R = (V_{OH} - 2.2\ V) / 10\ mA$$

Consulting the V_{OH} vs I curve for the output pin we find that at 10 mA V_{OH} = 4.4 V. We therefore need a resistance of 220 ohms. For the second figure, in which the LED is driven by an output low, the value of the current limiting resistor is calculated as,

$$R = (V_{DD} - 2.2\ V - V_{OL}) / 10\ mA$$

Consulting the V_{OL} vs I curve for the output pin we find that at 10 mA V_{OL} = 0.6 V. Using this value and using V_{DD} = 5V we find that this circuit also requires a resistance of 220 ohms.

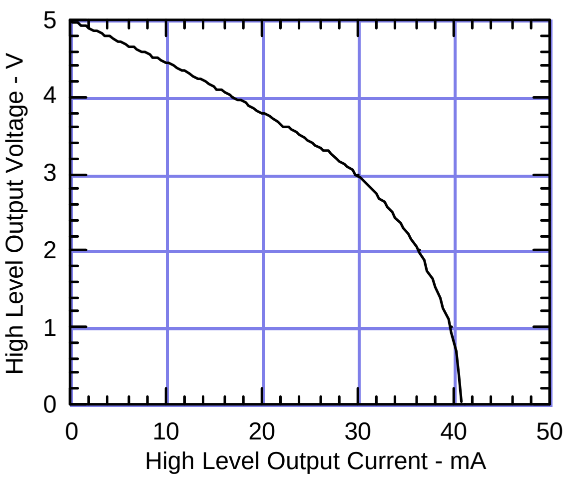

Figure 1

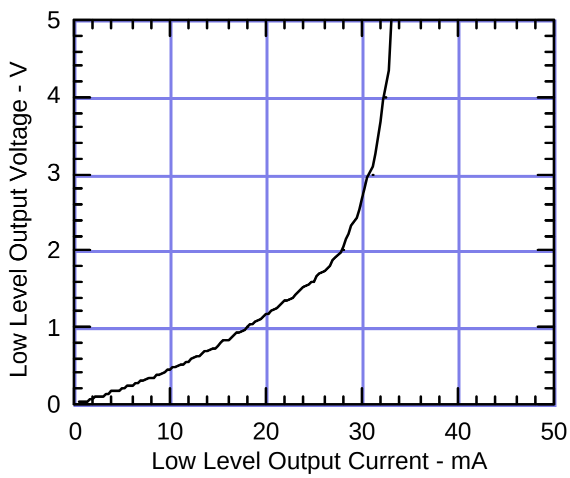

Figure 2

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