Application Report
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Applying the Current DAC on the TSC2000, TSC2200, TSC2300, and TSC2301 Touch Screen Controllers

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ABSTRACT

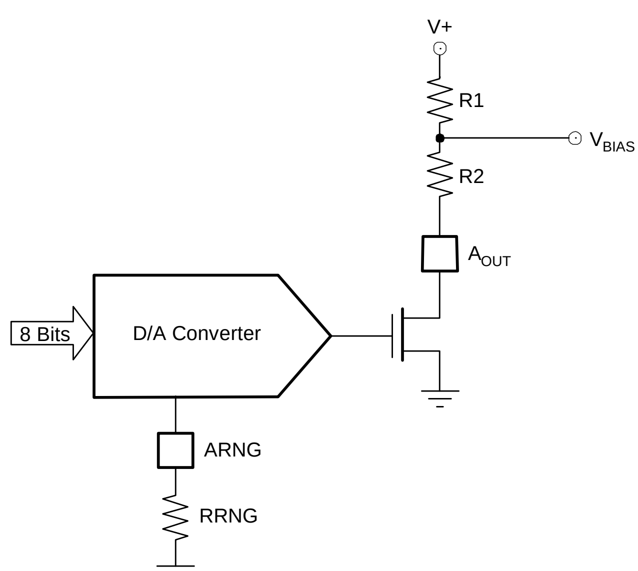
The TSC2000, TSC2200, TSC2300, and TSC2301 touch screen controllers all feature an 8-bit current-output DAC, which was intended for use as an LCD contrast adjustment. Some of the parametric limitations on the DAC may make it seem that it would not be useful for some applications; this application note shows some simple ways to overcome these apparent “limitations.”

Basic DAC Configuration

Pullup Voltage Less Than or Equal To the TSC Power Supply

The TSC2000, TSC2200, TSC2300, and TSC2301 touch screen controllers (hereafter referred to as the “TSCs”) have an on-board 8-bit D/A converter (DAC), outlined in Figure 1. This configuration yields a current sink (AOUT) controlled by the value of a resistor connected between the ARNG pin and ground. The eight-bit data is written to the D/A converter through the DAC data register in these devices.

Figure 1. D/A Converter Configuration

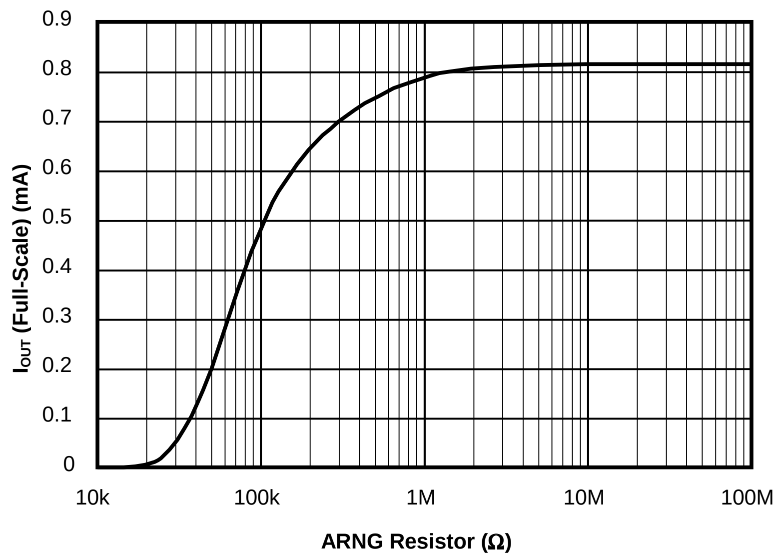


This circuit is designed for flexibility in the output voltage at the Vbias point shown in Figure 1 to accommodate the widely varying requirements for LCD contrast control bias. V+ can be a higher voltage than the supply voltage for the TSCs. The only restriction is that the voltage on the AOUT pin can never go above the absolute maximum rating for the device, and should stay above 1.5V for linear operation.

The DAC has an output sink range that is limited to 1mA. This range can be adjusted by changing the value of RRNG, shown in Figure 1. As this DAC is not designed to be a precision device, the actual initial value of the output current range can vary as much as ± 20%. Furthermore, the current output will change due to variations in temperature; the DAC has a temperature coefficient of approximately –2µA/°C.

To set the full-scale current, RRNG can be determined from the graph shown in Figure 2.

Figure 2. DAC Output Current Range vs ARNG Resistor Value



For example, consider an LCD that has a contrast control voltage V_{BIAS} which can range from 2V to 4V, and draws 400µA when used, with an available +5V supply. Note that this is higher than the TSC 3V supply voltage, but within the absolute maximum rating.

The maximum V_{BIAS} voltage is 4V, which occurs when the DAC current is 0. Thus, only the 400µA load current I_{LOAD} will be flowing from 5V to V_{BIAS}. This means 1V will be dropped across R1, so R1 = 1V/400µA = 2.5KΩ.

The minimum V_{BIAS} is 2V, which occurs when the DAC current is at its full-scale value, I_{MAX}. In this case, 5V-2V = 3V will be dropped across R1, so the current through R1 will be 3V/2.5K = 1.2mA. This current is I_{MAX} + I_{LOAD} = I_{MAX} + 400µA, so I_{MAX} must be set to 800µA. According to Figure 2, this means that RRNG should be around 1MΩ.

Since the voltage at the AOUT pin should not go below 1.5V, this limits the voltage at the bottom of R2 to be 1.5V minimum; this occurs when the DAC is providing its maximum current, I_{MAX}. In this case, $I_{MAX} + I_{LOAD}$ flows through R1, and I_{MAX} flows through R2. Thus,

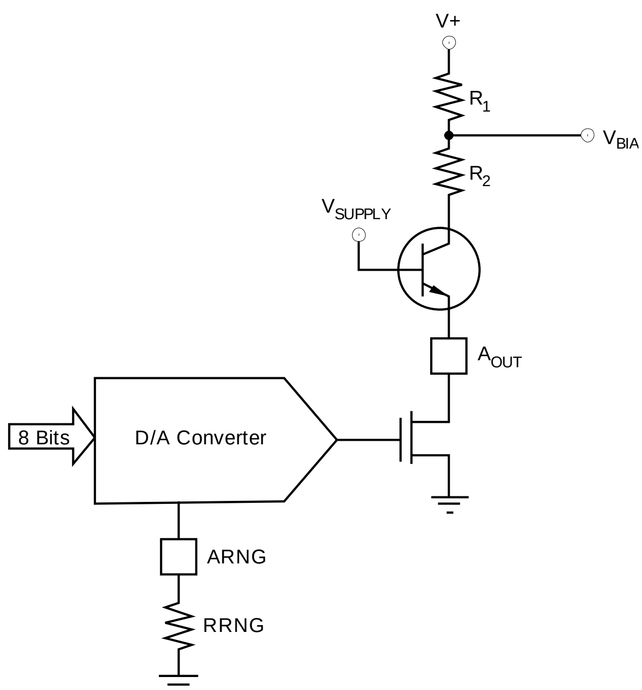
$$R_2 I_{MAX} + R_1 \left(I_{MAX} + I_{LOAD} \right) = 5V - 1.5V = 3.5V \qquad \text{Equation 1}$$

We already have found R1=2.5K, I_{MAX} = 800µA, I_{LOAD} = 400µA; we can now solve Equation 1 for R2 and find that it should be 625Ω.

Pullup Voltage Greater Than the TSC Power Supply

In the previous example, when the DAC current is zero, the voltage on the AOUT pin will rise above the TSC supply voltage. This is not a problem, however, since V+ was within the absolute maximum rating of the device; no special precautions are necessary. Many LCD displays require voltages much higher than the absolute maximum ratings of the TSCs. In this case, the addition of an NPN transistor, as shown in Figure 3, will protect the AOUT pin from damage.

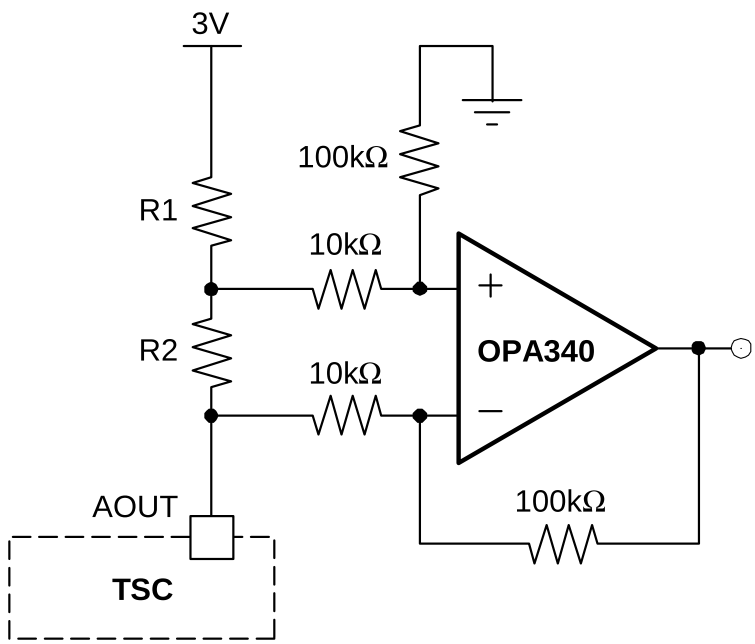
Figure 3. DAC Circuit when Using V+ Higher than Vsupply.



Extending the Output Voltage Range Below 1.5V

The addition of a differential amplifier eliminates the problem of having to have at least 1.5V on the AOUT pin, allowing the adjustable voltage from the DAC for LCD contrast control to go to 0V, if a bipolar or rail-to-rail op amp is used. The circuit connection is shown in Figure 4.

Figure 4. Adding a Differential Amplifier



R1 and R2 must be chosen so that at the maximum DAC current, the desired output voltage, divided by the gain of the differential amplifier, is present across R2. In this example, we will assume that the maximum DAC current is 700µA, and that the desired output swing is 0V to 1.6V. Note that the gain in this example is 10.

With a 3V supply voltage, and with AOUT being at least 1.5V, 1.5V is dropped across R1+R2. Thus,

$$1.5V = 700\mu A\left(R_1 + R_2\right) \qquad \text{Equation 2}$$

Solving Equation 2 shows that R1+R2 should be 2.1kΩ. Now, at 700µA, we want 1.6V/10 = 0.16V dropped across R2. Solving for this, we find that R2 should be 228Ω. If we were to use easily available standard values, setting R2 = 270Ω and R1 = 1.8K, we would have a system that would provide an output swing of 0 to 1.89V. If the output must be limited to 1.6V, then a value closer to the 228Ω should be found for R2, and R1 adjusted accordingly.

References

1. *TSC2200 datasheet* (SBAS191)

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