

APPLICATION NOTE 1031

Low-Power 3V ADC is 0.05% Linear

Abstract: This application note describes using a microcontroller (μC) with integrated digital-to-analog converter (DAC) and comparators to create a low cost ADC that is 0.05% linear.

The simple 3V analog-to-digital converter (ADC) shown in **Figure 1** is very small, requires no negative supply or expensive precision components, and draws minimal supply current ($10\mu\text{A}$). A single conversion consists of 12,000 comparisons and takes about 300ms. The circuit operates as described below.

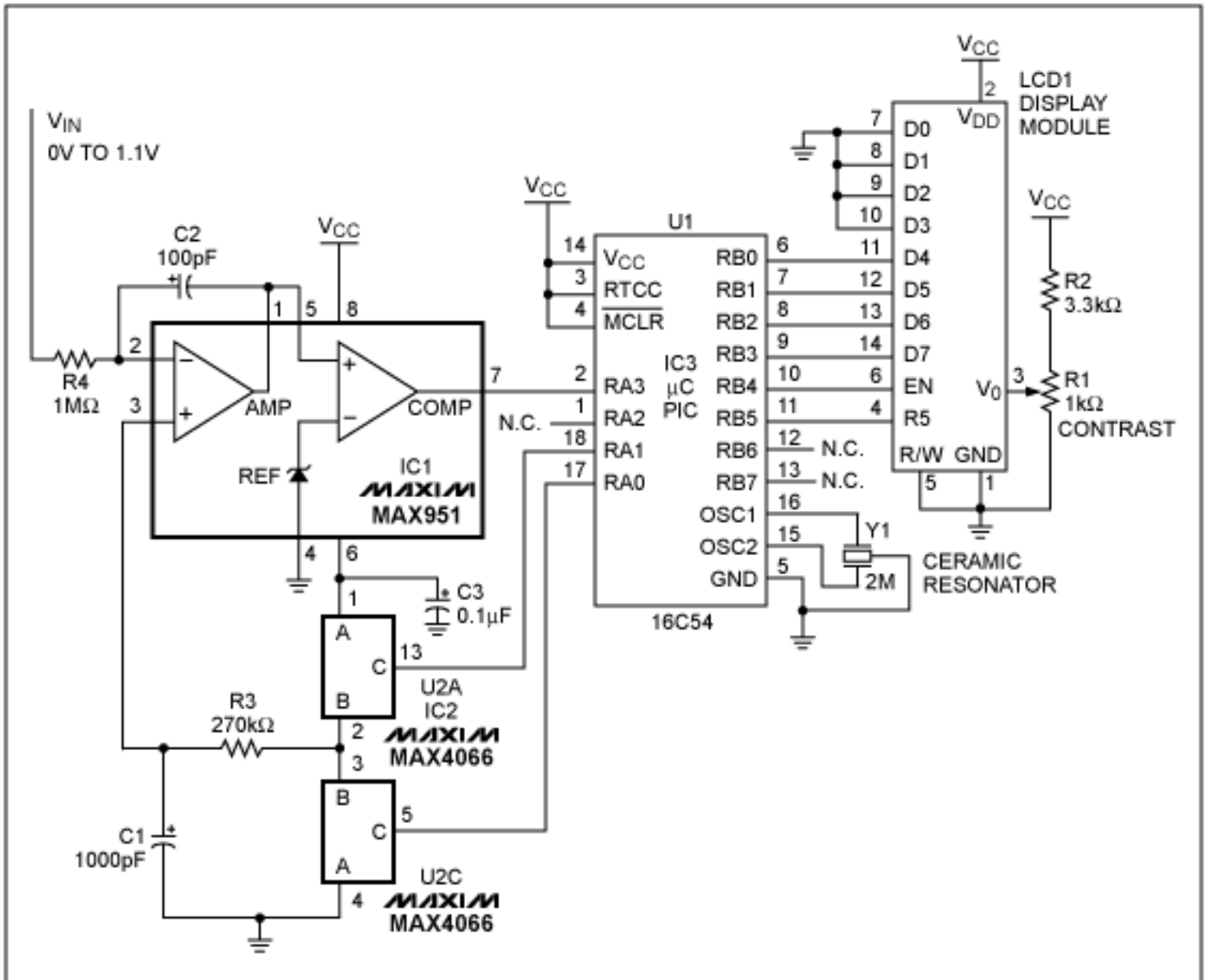


Figure 1. This inexpensive, 0.05%-linear ADC can be added to existing equipment or used to upgrade the converter included in certain μC s (such as the PIC 16C71).

Following each comparison, the microcontroller (μC) closes one of two switches: IC2A (comparator high) or IC2B (comparator low). The switches connect either V_{REF} (1.2V) or ground to their "B" terminals, producing a pulse-width modulation (PWM) signal that is filtered by R3 and C1 and differentially integrated against V_{IN} . The result is compared against V_{REF} .

As this action integrates the error voltage up and down, the μC counts the number of comparisons for which the comparator output is high (IC2A switch closed). This count (N_{H}) divided by 12,000 equals the PWM duty cycle.

The system is fully ratiometric, so the duty cycle equals $N_{\text{H}}/12000 = V_{\text{IN}}/V_{\text{REF}}$. Rearranging and substituting $V_{\text{REF}} = 1.2\text{V}$ yields $V_{\text{IN}} = N_{\text{H}}/10,000$.

Listing 1* enables the the LCD module to display voltage values directly, like a digital panel meter. The subroutine "DVM" produces the actual A/D-conversion values required in an embedded application. Setting the span constant (number of comparisons) to 12,000 yields a 300ms conversion with 4-1/2 digits of resolution and produces a 1.1999 full-scale display. You can speed the conversion to 30ms by setting the span constant to 1200, which produces a 3-1/2 digit display that reads 1.199 at full scale.

IC2's near-ideal switching characteristics account for the low 0.05% nonlinearity. A high-performance, 3V-specified version of the industry standard 4066, IC2 is a quad analog switch that features 35Ω on-resistances and 0.1nA (max) off leakages. You can save space by replacing IC2 with the MAX323 dual analog switch: a 3V single-pole/single-throw device with specifications similar to those of the MAX4066. The MAX323 resides in an 8-pin μMAX package (versus a 14-pin SO for the MAX4066).

V_{CC} is limited to the maximum allowed by the μC (6V). IC1, which operates with V_{CC} as low as 2.8V over temperature, draws only $7\mu\text{A}$ of supply current. The voltage reference in IC1 is stable for capacitive loads smaller than 100pF or larger than $0.05\mu\text{F}$. To ensure stability, the reference's external bypass capacitor (C3) should be kept large.

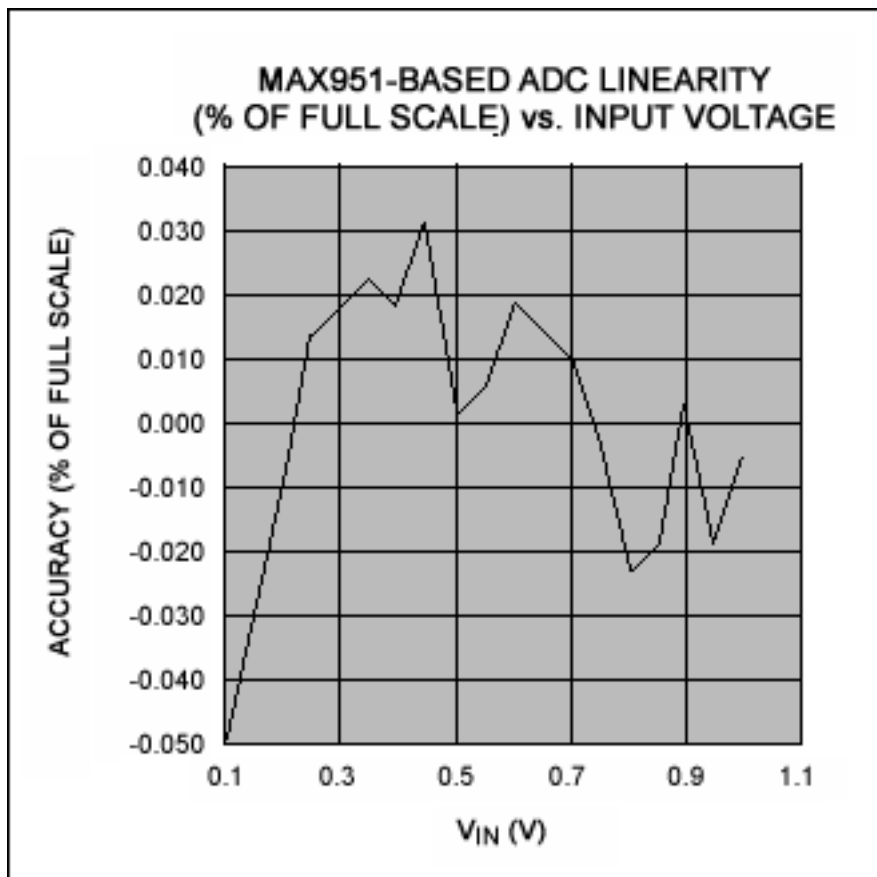


Figure 2. In Figure 1, the output nonlinearity (as a percentage of full scale) varies as shown.

A similar version of this article appeared in the June 19, 1997 issue of *EDN* magazine.

Application Note 1031: <http://www.maxim-ic.com/an1031>

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Related Parts

MAX4066: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)

MAX951: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)

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