

## High Voltage CMOS Amplifier Enables High Impedance Sensing with a Single IC – Design Note 513

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### Introduction

Accurately measuring voltages requires minimizing the impact of the instrument connection to the tested circuit. Typical digital voltmeters (DVMs) use 10M resistor networks to keep loading effects to an inconspicuous level, but even this can introduce significant error, particularly in higher voltage circuits that involve high resistances.

The solution is to use high impedance amplifiers in an electrometer configuration, so only miniscule amplifier input current comes from the test node. To make the input current the lowest possible value, field-effect transistors (FETs) are traditionally employed at the inputs of these circuits. FETs are generally low voltage devices, and introduce voltage offset uncertainty that is difficult to eliminate. Monolithic amplifiers exist that incorporate FET inputs, but these are often very low voltage devices, especially those using typical CMOS fabrication methods, so their utility is limited in high voltage applications. Enter the **LTC<sup>®</sup>6090**, a CMOS amplifier that can handle over 140V<sub>P-P</sub> signal swings with sub-mV precision, ideally suited to tackle the problem.

### The LTC6090 Easily Solves High Voltage Sensing Problems

The LTC6090 combines a unique set of characteristics in a single device. Its CMOS design characteristics provide the ultimate in high input impedance and “rail-to-rail” output swing, but unlike typical CMOS parts that might be powered by 5V, the LTC6090 can operate with supplies up to ±70V. The device can hold its own in the small-signal regime as well, featuring typical  $V_{OS}$  under 500 $\mu$ V and voltage-noise density of 11nV/ $\sqrt{\text{Hz}}$ , yielding a spectacular dynamic range. With the high voltage operation comes the possibility of significant power dissipation, so the LTC6090 is available in thermally-enhanced SOIC or TSSOP packages. It includes an overtemperature output flag and an output disable control that provide flexible protection measures without additional circuitry.

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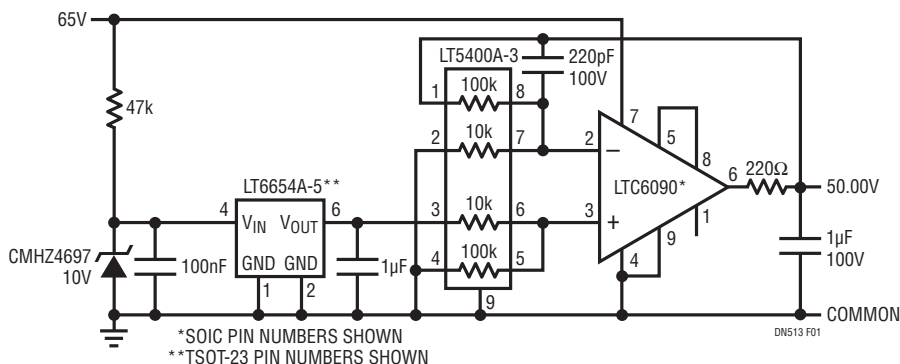


Figure 1. High Voltage Precision Reference

## Accurate 50.00V Reference

The LTC6090 is capable of 140V output levels in single-supply operation, so amplifying a quality 5V reference is a simple matter of using accurate resistor networks to maintain precision. The LT<sup>®</sup>5400 precision resistor array handles voltages up to 80V, so utilizing the 10:1 ratio version for a gain of 10 is an easy way to produce an accurate 50V calibration source without any adjustments required. Figure 1 shows a circuit amplifying the LT6654A 5.000V reference to 50.00V with better than 0.1% accuracy. The circuit may be powered from 55V to 140V, with 65V being a useful supply voltage furnished from the optional portable supply shown as part of Figure 2.

The LTC6090 is set up with a 1 $\mu$ F output capacitance to provide excellent load-step response. The capacitance is isolated from the op amp with a resistance that forms an effective noise-reduction filter for frequencies above 700Hz. The precision LT5400A-3 resistor network provides 0.01% matched 10k/100k resistances that, along with the absence of loading by the high impedance CMOS op amp inputs, forms a highly accurate amplification factor. Input offset voltage of the LTC6090 contributes <0.03% error, while the LT6654A contributes <0.05%.

The entire circuit of Figure 1 draws about 4mA of quiescent current and can drive 10mA loads.

## Simple Large-Signal Buffer

The LTC6090 behaves as an ordinary unity-gain-stable operational amplifier, so constructing an electrometer-grade buffer stage is simply a matter of providing 100% feedback with the classic unity-gain circuit. No discrete FETs or floating biasing supplies are needed.

As shown in Figure 2, the LTC6090 can easily be powered with a split supply, such as a small flyback converting battery source. This basic circuit can provide precision measurement of voltages in high impedance circuitry and accurately handle signal swings to within 3V of either supply rail ( $\pm 62V$  in this case). With input leakage current typically below 5pA, circuit loading is essentially inconsequential ( $<V_{OS}$ ) for source impedances approaching a gigaohm. The useful full-swing frequency response is over 20kHz.

## Conclusion

The LTC6090 is a unique and versatile high voltage CMOS amplifier that enables simplified high impedance and/or large signal swing, very wide dynamic range amplification solutions.

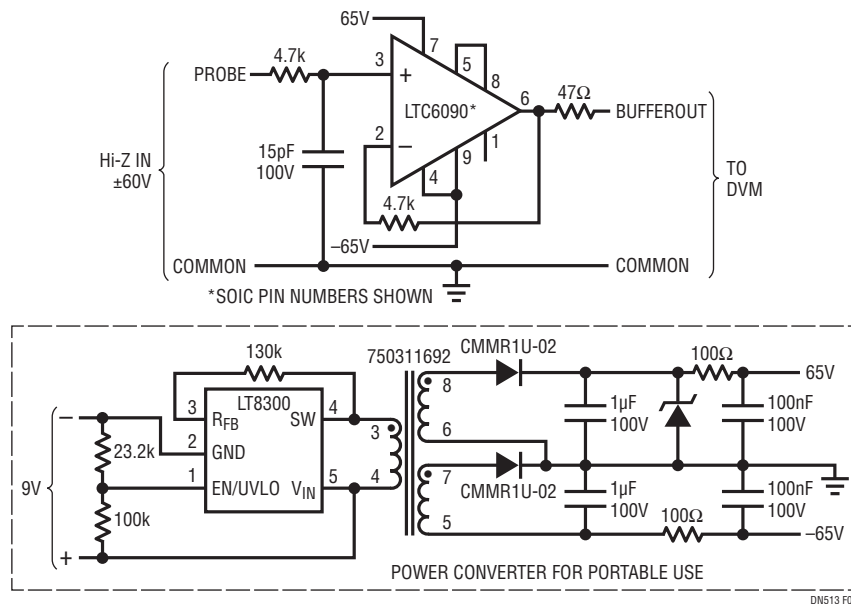


Figure 2. Buffered Probe for Digital Voltmeter

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