

Stacking the REF50xx for High-Voltage References

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ABSTRACT

This application note describes the additional ways of using the [REF50xx](#). The application described in this note creates a reliable device with unique characteristics, which allows voltage references to be connected serially.

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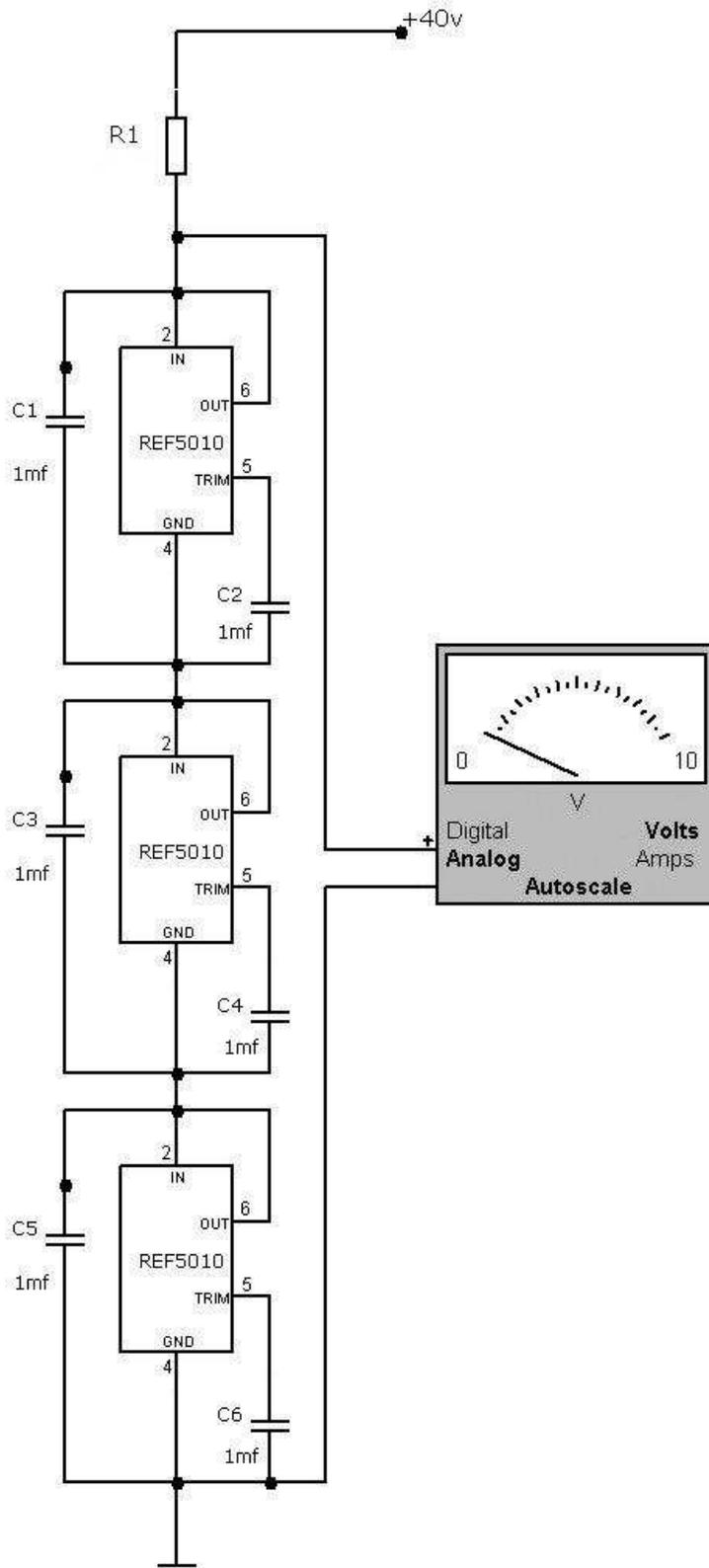
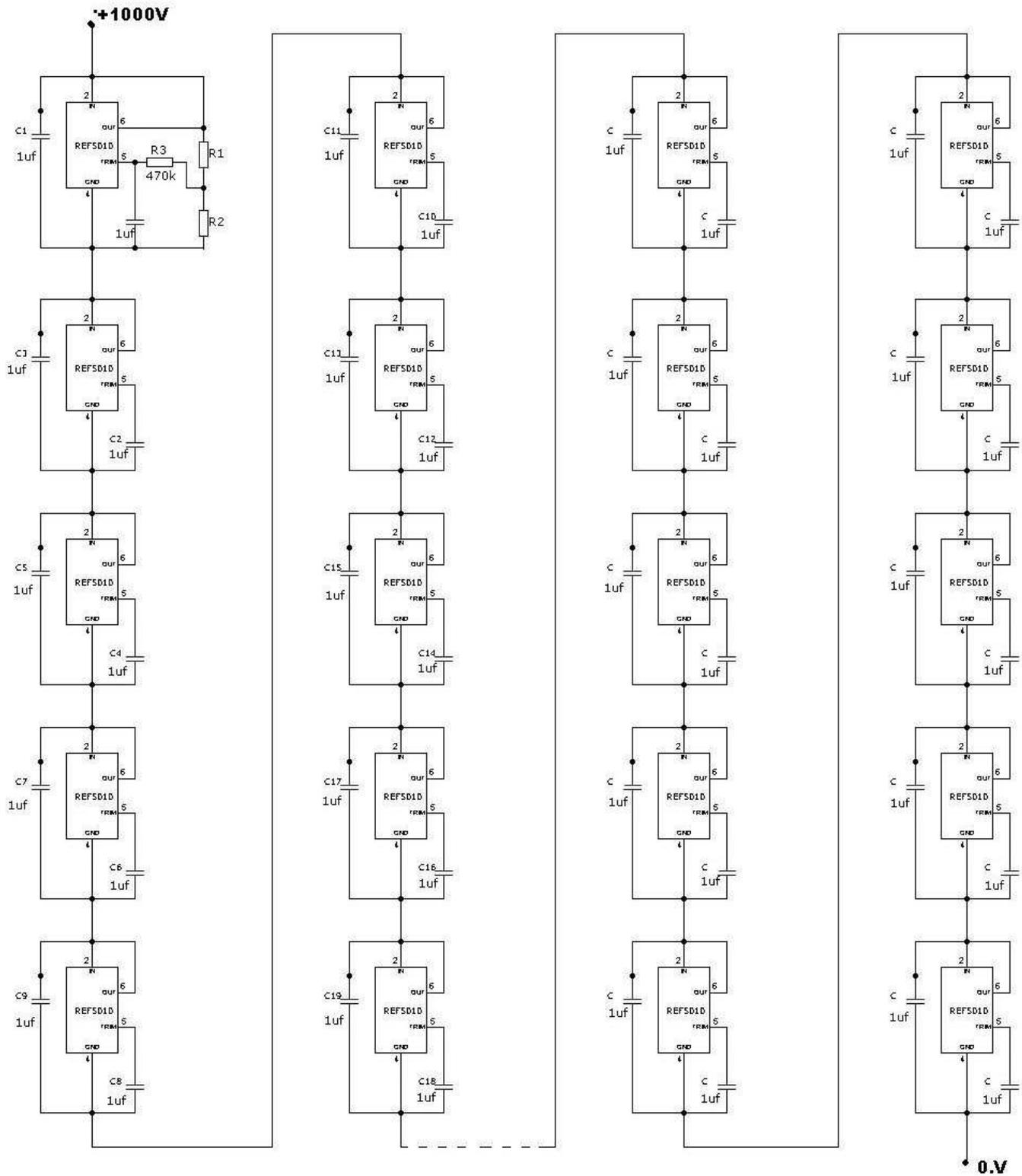


Figure 2. REF5010 Connected Serially as Usual Zener Diodes

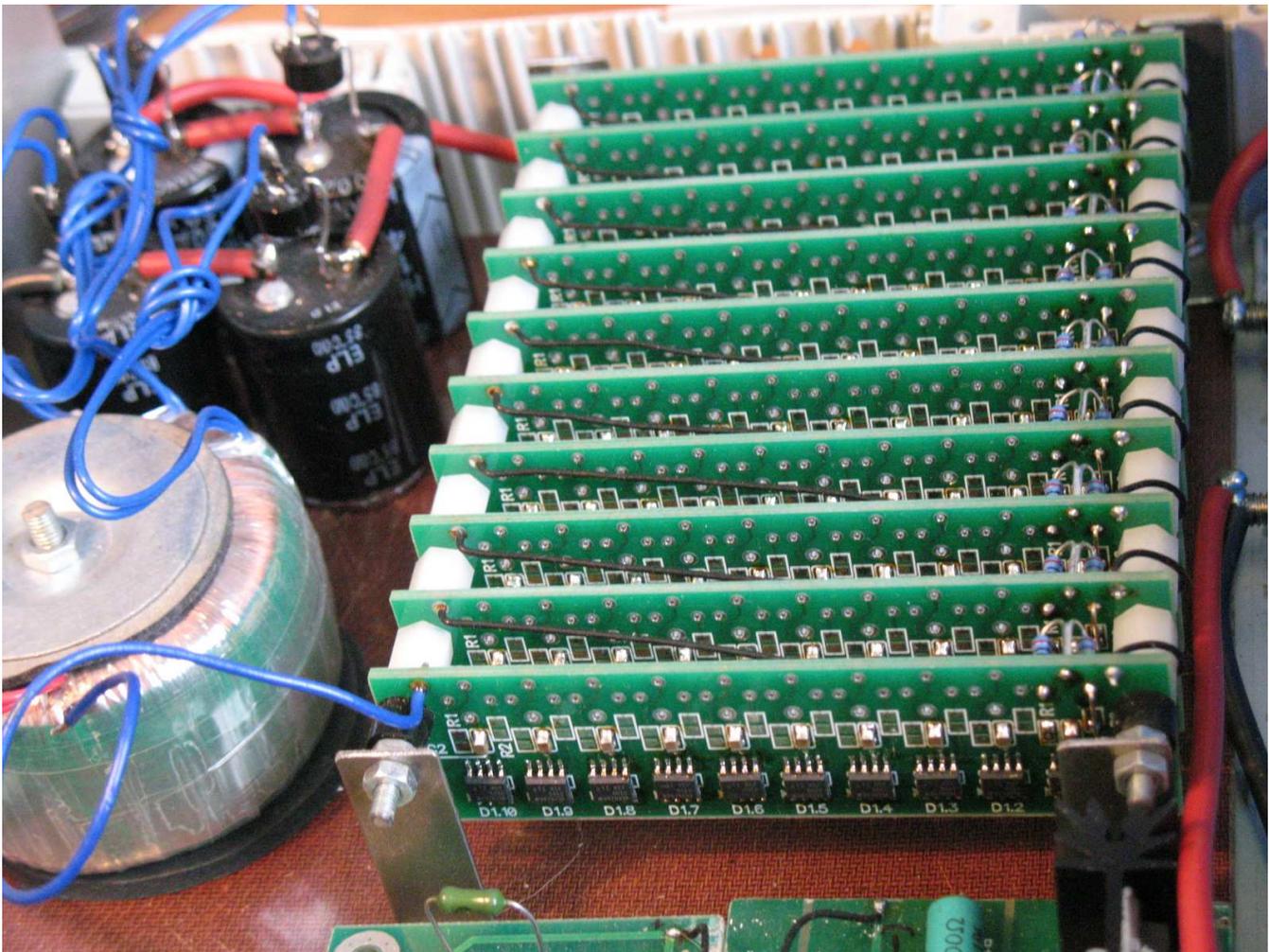
Experiments performed with the schematic of [Figure 2](#) demonstrated the same results as the experiments from [Figure 1](#). If the current regulated by R1 stays within the range of 3 mA to 8 mA, the output voltage remains stable and is equal to three times the specified voltage of the REF5010 data sheet. The same results are confirmed with other REF50xx device family members.

The precision 1000-V reference voltage source is designed by serially connecting 100 REF5010 devices. Each REF5010 is configured as a two-terminal device. Together, the devices create a 1000-V precision reference source. The top left REF5010 device functions as a voltage adjuster that allows the targeted 1000-V to be set more precisely. However, there is little need for fine tuning because the 100-part averaged value is very close to the ideal 10 V despite some part-to-part variation. The small range of adjustment needed only confirms the statement that if normal distribution is present, a precision device can be built without using precision components. Refer to [Figure 3](#). [Figure 4](#) illustrates the interior view of the 1000-V voltage source.



NOTE: 100 REF5010 devices are used.

Figure 3. Schematic of 1000-V Reference Voltage Source



NOTE: Each board creates a 100-V reference.

Figure 4. 1000-V Reference Voltage Source, Interior View

2 1000-V Reference Voltage Source Characteristics

Ten 1000-V reference voltage sources were made. Before the PC boards are installed into the final device, each board goes through thermo training and thermo cycling for 120 hours, according to ISO 9000. The precision and stability of the voltage sources are regularly checked during 3.5 months using the HP3458A digital voltmeter.

The conclusions are:

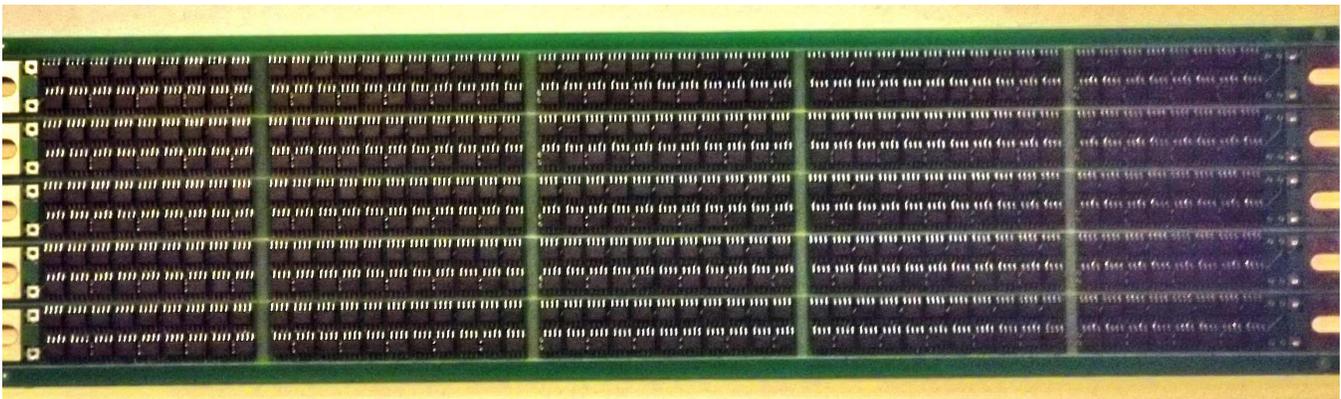
1. Two hours are required to achieve the declared precision corridor of ± 5 ppm.
2. 24 hours are required for the output voltage to stabilize in the precision corridor of ± 2.5 ppm.
3. After stabilizing, the 24-hours change is within ± 3 ppm. The most significant voltage difference between 10 devices after 48 hours is 7 ppm. The most significant voltage difference between devices after 72 hours is 3 ppm to 4 ppm.
4. The average voltage sources output value after 3.5 months is 1000.022 V.

Using the REF50xx two-terminal schemes allows building high-voltage reference sources for any voltage, including sources for tenths of kilovolts.

Currently, the voltage source for 100 kV is built using this method. 10000 REF5010 devices are used to build this device. This design probably hits the record of simultaneous use of TI parts in a single device. Its electrical parameters are under characterization.

[Figure 5](#) shows the board that contains 500 serially connected REF5010 devices. The board is later cut into five 100-V strips to obtain better isolation. Together, these strips produce a 5-kV voltage stage.

A 100-kV reference voltage source is depicted in [Figure 6](#).



NOTE: Full board view before being cut into 100-V strips.

Figure 5. 100-kV Reference Voltage Using a REF5010 as the Base Element



NOTE: The boards are located inside the cylinder.

Figure 6. Common View of a 100-kV Reference Voltage Source

2.1 Conclusion

The two-terminal application scheme of the REF50xx has excellent characteristics and features that are closely related to an ideal Zener diode. Serial connections of these blocks allow high voltage reference sources to be built for any voltage with very high precision and stability. Unfortunately, the requirement for additional pins used for package-level trim during device production trimming prevents this ideal two-terminal Zener diode from being offered as a standard device.

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