

# High-Precision, Ultra-Stable Voltage Reference Hybrid Devices

CERAMIC PACKAGING AND LASER TRIMMING YIELD DEVICES THAT ARE EXCEPTIONALLY WELL SUITED FOR EXTENDED TEMPERATURE RANGE APPLICATIONS IN MILITARY AND OTHER HARSH ENVIRONMENTS ( $-55^{\circ}\text{C}$  TO  $+125^{\circ}\text{C}$ )

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## INTRODUCTION

The Cirrus Logic family of precision voltage references are hybrid circuits that include all the necessary active and passive components on a ceramic substrate—no external circuitry is necessary, only the power needs to be supplied and the reference will provide a stable output voltage. Featuring the technology of Apex Precision Power<sup>®</sup>, these reference products achieve the highest accuracy and stability over both a wide temperature range and an extended period of time. This performance is achieved through the process of active laser trimming of a proprietary nonlinear network of film resistors, and by functionally testing every single part over the full operational temperature range.

## I. OPERATING PRINCIPLES OF HIGHLY PRECISE AND STABLE VOLTAGE REFERENCES

The operating principle is illustrated in the block diagram that follows. It is based on a zener diode—the most stable diode over time and temperature. A current source supplies the zener diode, and the zener voltage is then amplified to the desired value by a regulation feedback loop consisting of an error amplifier and a resistor compensation network.

The characteristic of the zener voltage vs temperature is highly non-linear. The output voltage initial precision and stability over temperature and time is highly dependent on the ability to compensate for this non-linearity of the zener voltage. This is particularly difficult to achieve over a wide temperature range such as  $-55^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ .

Cirrus Logic has solved this problem by using a proprietary network of non-linear and laser-trimmable film resistors in the amplifier compensation network. This network eliminates most of the non-linearity in the voltage vs temperature function.

## II. HYBRID MANUFACTURING, TESTING AND LASER TRIMMING

All voltage references are built in the Cirrus Logic facilities in Tucson, Arizona (USA), using a high quality, DSCC-certified hybrid manufacturing process. All the needed circuit parts such as ICs and small-signal components are attached to the ceramic substrate alongside thick and thin film resistors and interconnected with gold ball wire bonds. The film resistors are trimmable, a key characteristic offered by the hybrid manufacturing process and crucial for making ultra precise voltage references capable of performing over an extended temperature range.

After assembly is completed, the parts undergo an initial burn-in and electrical test sequence with the purpose



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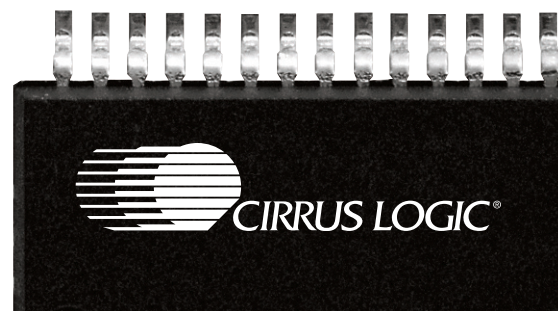
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of identifying early failures. Those parts with minor defects are re-worked and repaired.

Every functional part is then trimmed. The voltage references are powered up, and the output voltage is measured over the entire operating temperature range in comparison to the expected values. Data is collected for every single device tested and then proprietary software algorithms are used to drive the automatic lasers that trim the resistors. Every voltage reference needs to be trimmed differently with several iterations of this measure, and trim process is required until the voltage output meets the exacting specifications. Since these resistors are very stable, the voltage references have also very good long term stability.

After trimming is completed, the parts are sealed and undergo reliability testing that includes additional burn-in, temperature cycling, and acceleration tests. Fine and gross leak testing is also performed. In total, the highest graded parts spend up to one full day in trimming and seven days in reliability testing.

This extensive testing procedure ensures that only functional devices are delivered to the customer and that every shipped part will have the specified voltage precision over the entire  $-55^{\circ}$  to  $+125^{\circ}$  C temperature range. Early failures should never be an issue. Commercial and industrial grade parts are also available and optimized for temperature ranges of  $0^{\circ}$  to  $+70^{\circ}$  C,  $-25^{\circ}$  to  $+85^{\circ}$  C and  $-40^{\circ}$  to  $+85^{\circ}$  C.

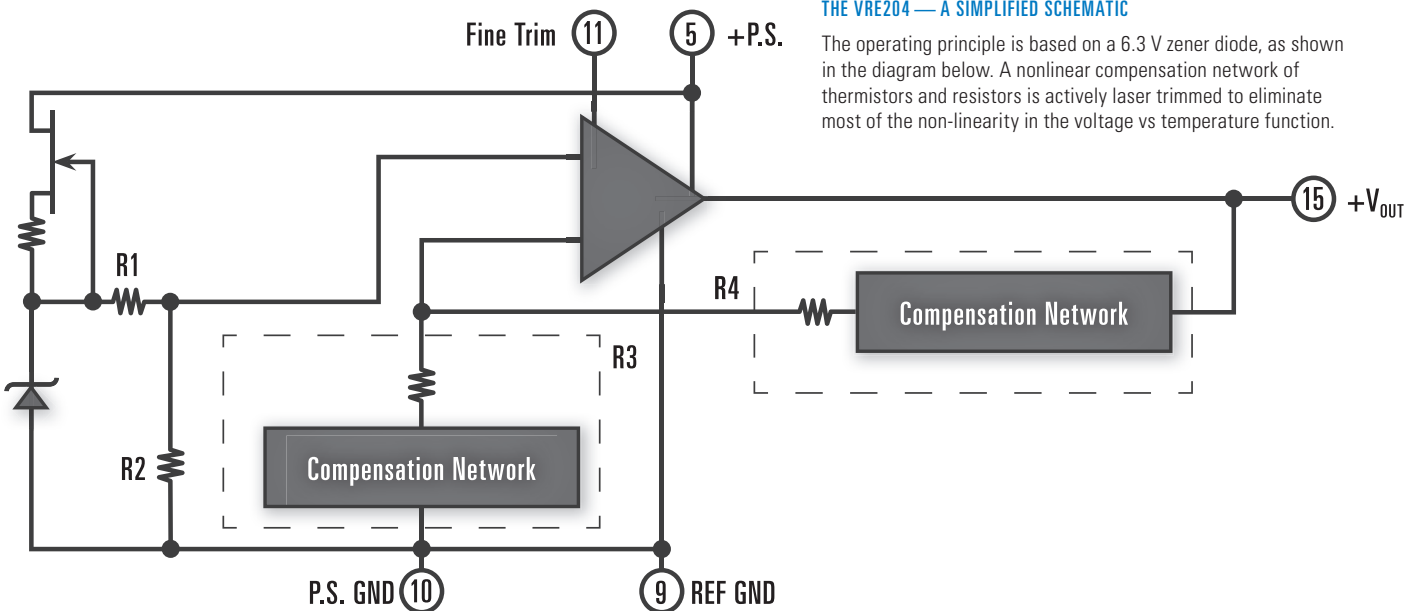
### III. TYPICAL APPLICATIONS AND ADVANTAGES

The key advantage of Cirrus Logic references is their excellent precision is achieved over a very wide temperature range without the need for over-temperature control. This advantage, combined with their unparalleled stability over time, provides clear advantages to high-end equipment manufacturers, such as the ability to achieve high measurement sensitivity and increased time between needed equipment calibrations. Target applications include:

- Automatic test equipment
- Medical devices
- Industrial process monitoring
- Precision motor control
- Ultra sensitive seismic sensor systems
- Fuel injection systems
- Guidance systems

The high quality and reliability provided by the hybrid manufacturing process, combined with ceramic packaging, makes these voltage references exceptionally well suited for equipment that operates in harsh outdoor environments:

- Environments with wide temperature swings, such as deserts
- Deep underground locations
- Airborne applications



THE VRE204 — A SIMPLIFIED SCHEMATIC

The operating principle is based on a 6.3 V zener diode, as shown in the diagram below. A nonlinear compensation network of thermistors and resistors is actively laser trimmed to eliminate most of the non-linearity in the voltage vs temperature function.

### IV. SUMMARY & CONCLUSIONS

Cirrus Logic voltage references deliver superior quality and reliability in a single-packaged, off-the-shelf solution that will trim design time and speed delivery to market. These products offer the designer voltage supply accuracy by providing low temperature drift and minimizing the impact of operating conditions on voltage delivery over time.

Cirrus Logic offers more than 50 models of these external voltage references rated as ultra stable at voltage outputs ranging from +2.5 V up to  $\pm 10$  V. Initial accuracies are as low as  $\pm 0.25$  mV and temperature coefficients as low as 0.6 ppm/ $^{\circ}$ C. This combination of best-in-class performance provides extremely low drift over the full military temperature range.

### V. REFERENCE

1. VRE204 Precision Voltage Reference Data Sheet