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Keywords: digital calibration, replacing potentiometers, automated testing, increased reliability, reduced test time, reduced test cost, digital potentiometer, calibration digipots, calibration voltage references, calibration DAC, non-volatile memory

TUTORIAL 5036

Calibration Circuit Library

By: Bill Laumeister, Strategic Applications Engineer

Jun 10, 2011

Abstract: This application note discusses the some of the benefits of digital calibration and shows common calibration circuits by application.

Calibration makes products accurate, safe, and affordable. It allows manufacturers to deliver "perfect" devices at competitive prices. Maxim's large variety of digital calibration parts enables quick automated testing and adjustment.

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These ideas are presented pictorially to save time and speed comprehension. Most engineers will spend a second or two on each block until one fits their application. They can then click on the diagram to jump to the source application note or datasheet for more information.

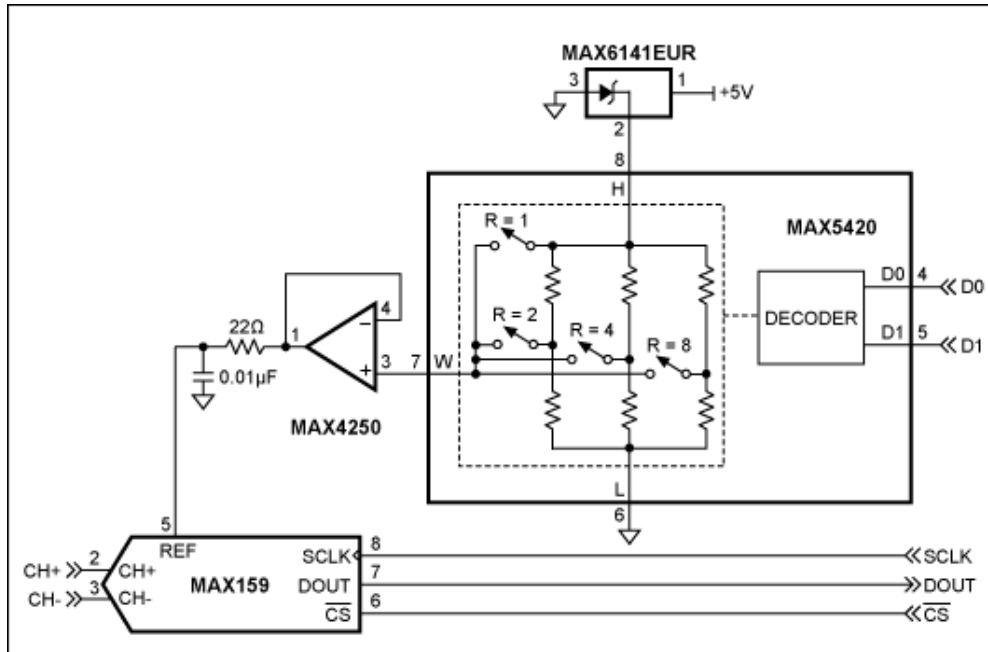
Electronic calibration can reduce cost in many areas. It can remove manufacturing tolerances, specify less-expensive components, reduce test time and customer returns, and improve reliability. It also increases customer satisfaction, lowers warranty costs, and speeds product delivery.

Digitally controlled calibration devices and potentiometers (pots) are replacing mechanical pots in many products. By removing human error, these parts reduce test time and expense. Additionally, digital devices are insensitive to vibration, dust, dirt, and moisture, which can cause failure in mechanical pots. The increased reliability can reduce product liability concerns and improve product safety. Furthermore, the small size of electronic calibration devices benefits small board layouts and portable devices.

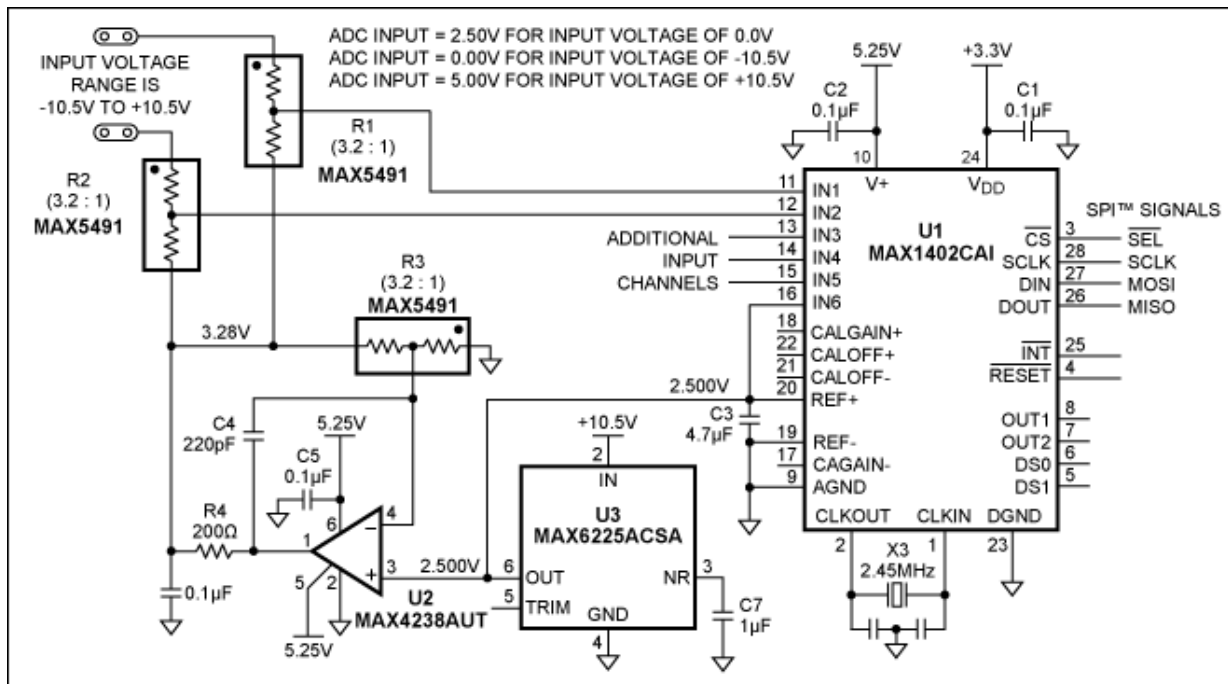
This application note shows some of the more common calibration circuits by application. More calibration design tips and tools are available at www.maximintegrated.com/cal.

Calibration Circuits by Application

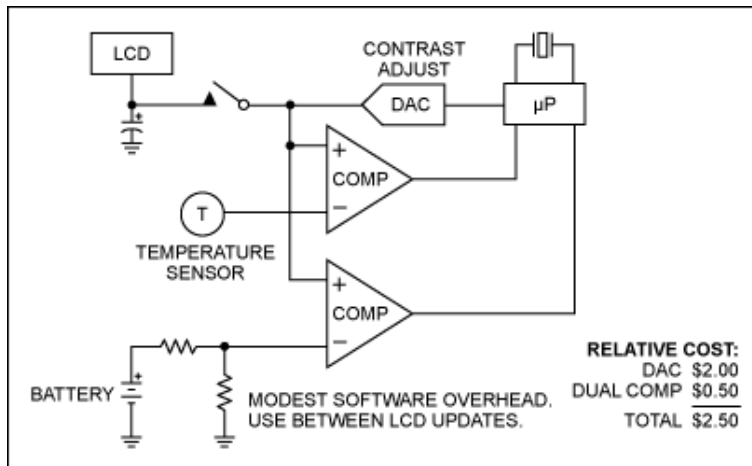
ADC



See application note 2013, "Voltage Reference Scaling Technique Increases ADC Accuracy to Keep Costs Down."

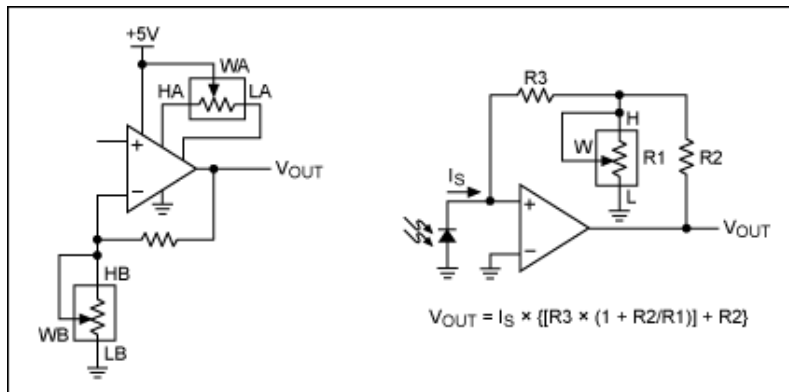


See application note 4617, "ADC Input Translator."

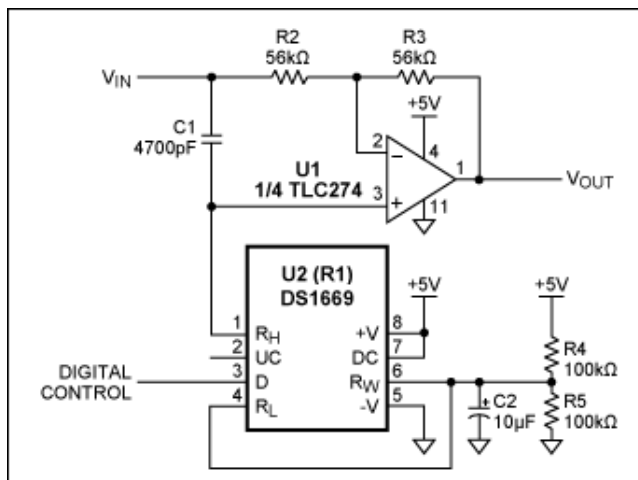


See application note 647, "Comparator/DAC Combinations Solve Data-Acquisition Problems."

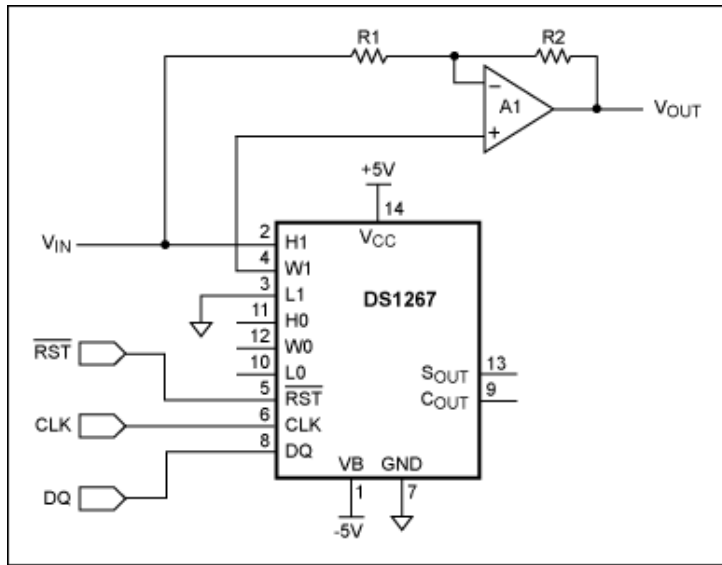
Amplifier Support



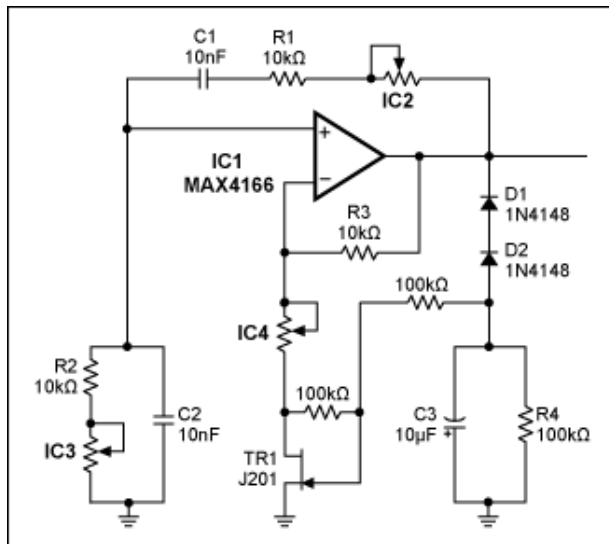
See the [MAX5389 data sheet](#).



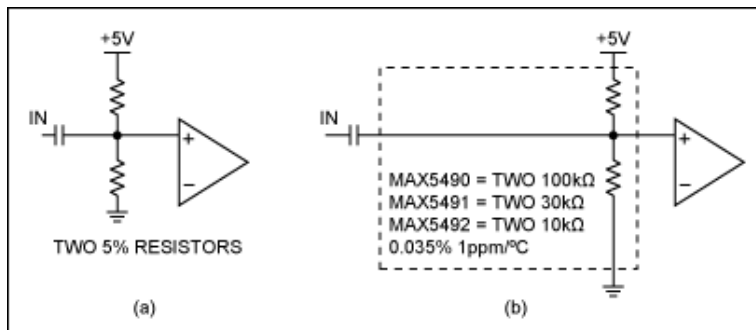
See application note 184, "Digitally-Controlled Phase Shift Using the DS1669."



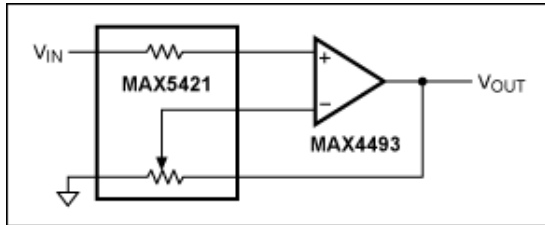
See application note 558, "Tech Brief 2: Dual-Polarity Amplifier is Controlled Digitally."



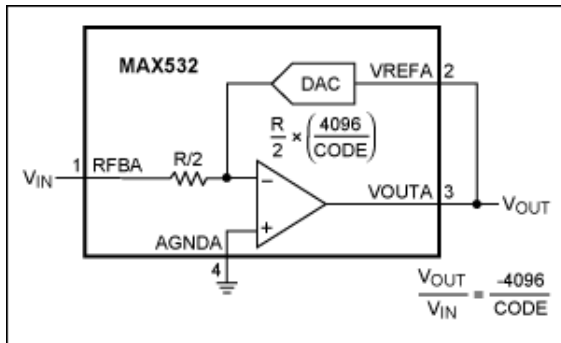
See application note 3846, "Analysis of a Digitally Controlled Wien-Bridge Oscillator."



See application note 4344, "[Rail Splitter, from Abraham Lincoln to Virtual Ground.](#)"

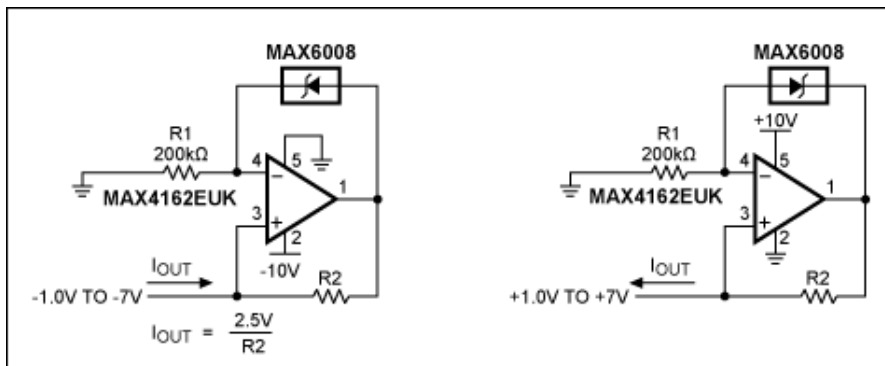


See application note 4348, "[Minimize Voltage Offsets in Precision Amplifiers.](#)"

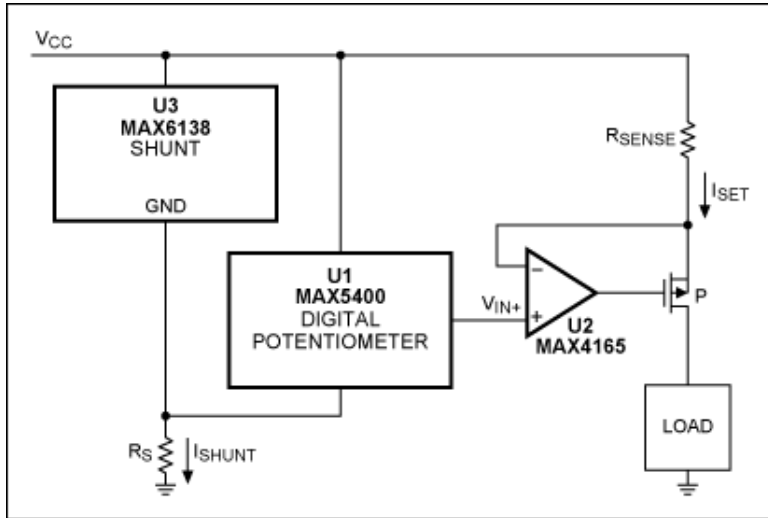


See application note 429, "[Programmable-Gain Amplifier, Using the MAX532 DAC.](#)"

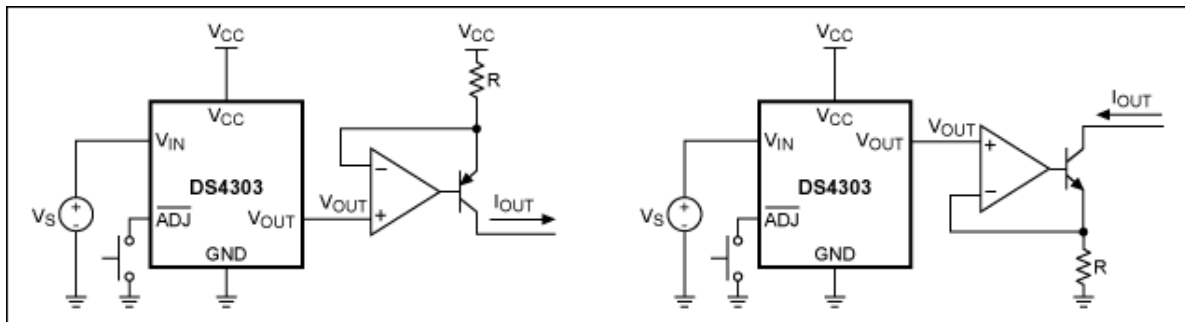
Current Source/Sink



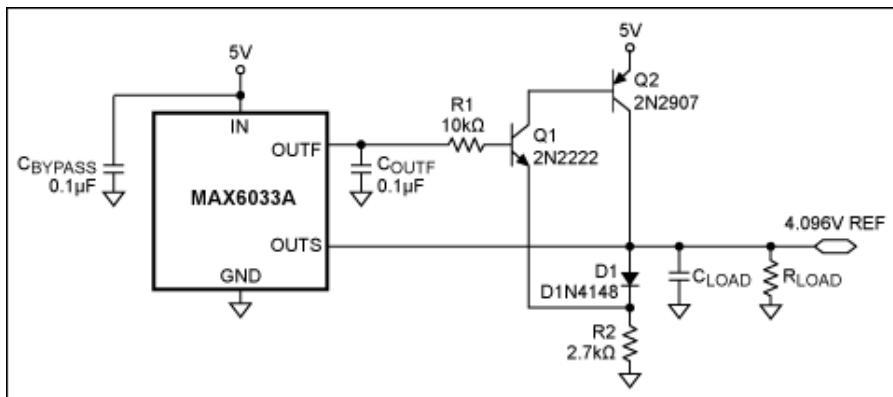
See the [MAX6008 data sheet](#).



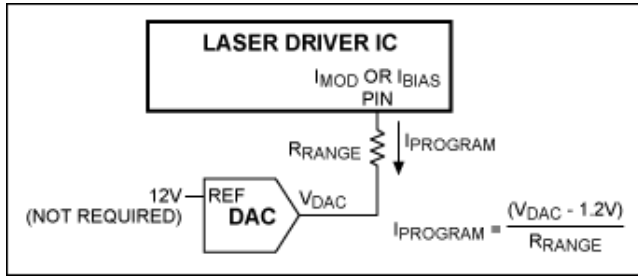
See application note 3464, "[Precision Current Source is Software-Programmable.](#)"



See application note 3748, "[How to Create a Precision Current Source Using a DS4303 or DS4305.](#)"

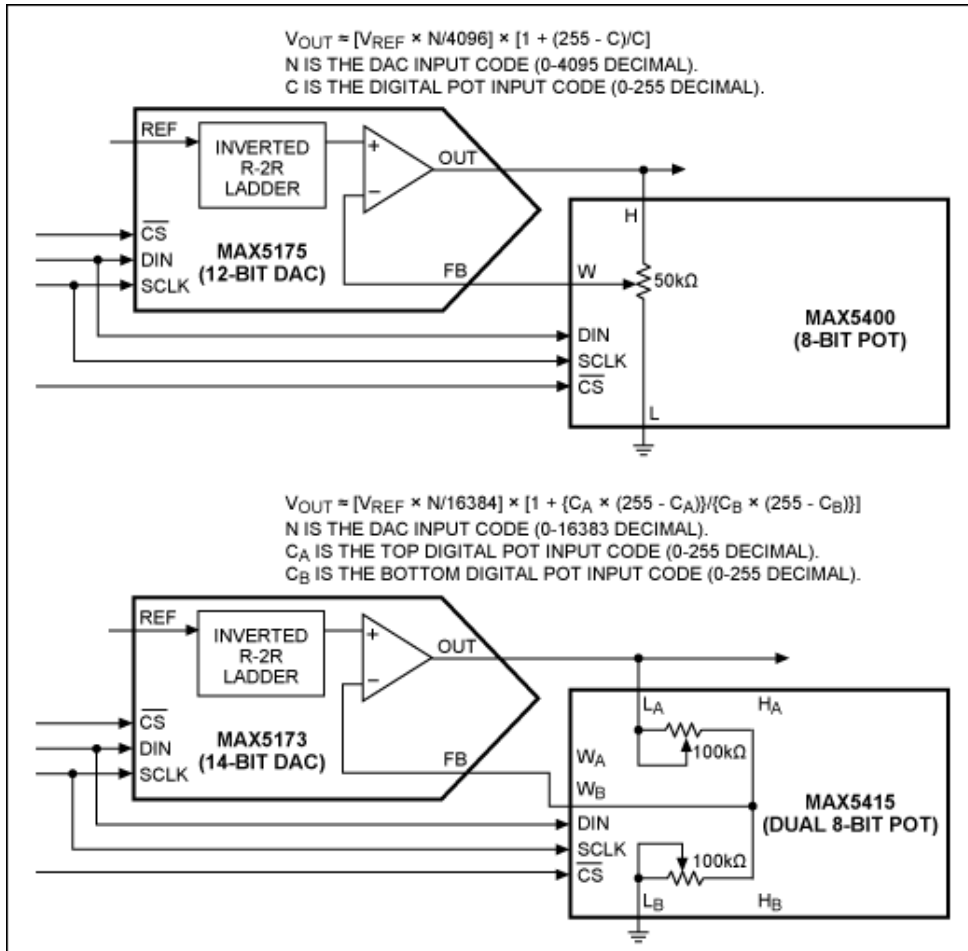


See application note 4474, "[4.096V, 80mA Precision Reference.](#)"

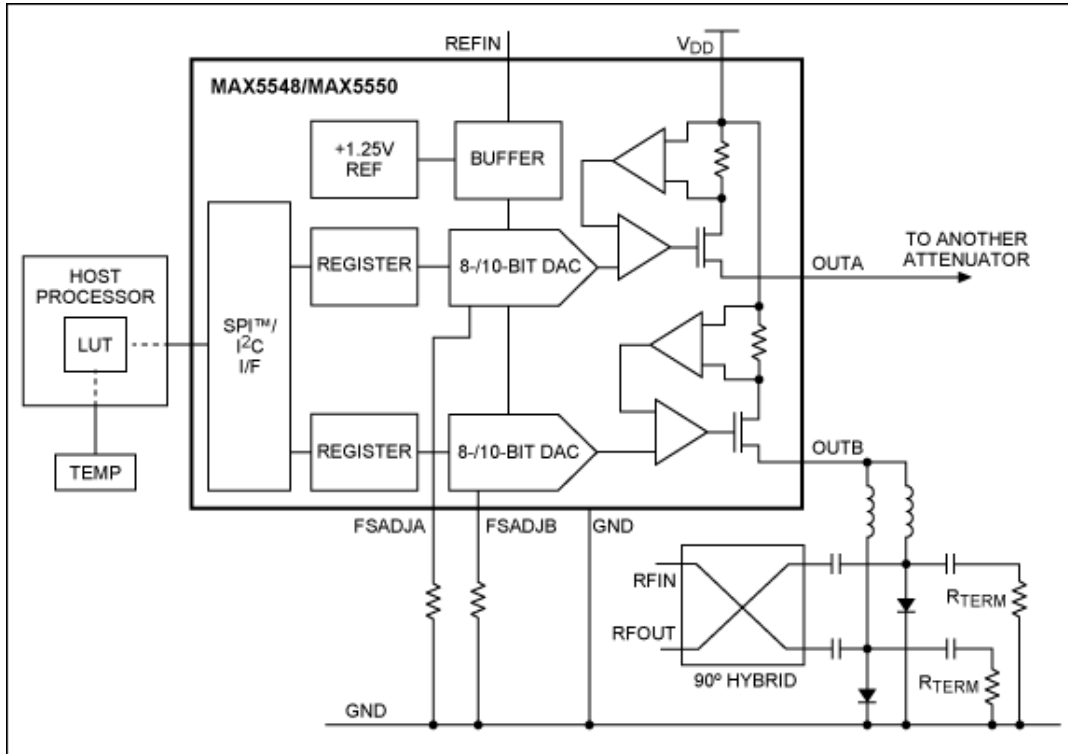


See application note 1010, "Methods of Controlling Laser Drivers: POTs and DACs."

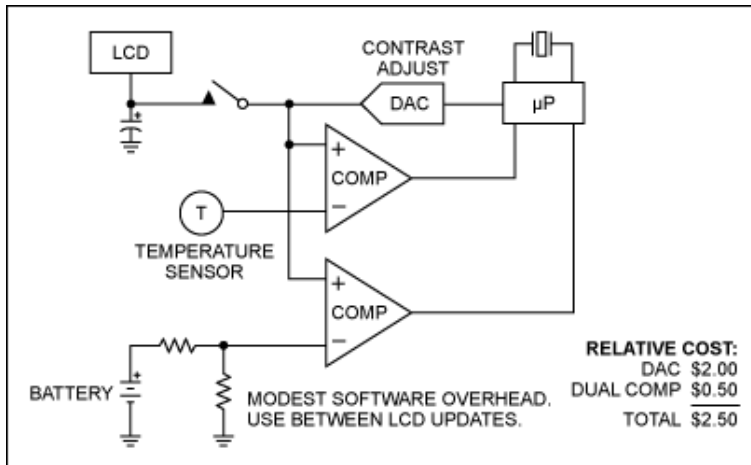
DAC



See application note 807, "Force/Sense DAC Applications."

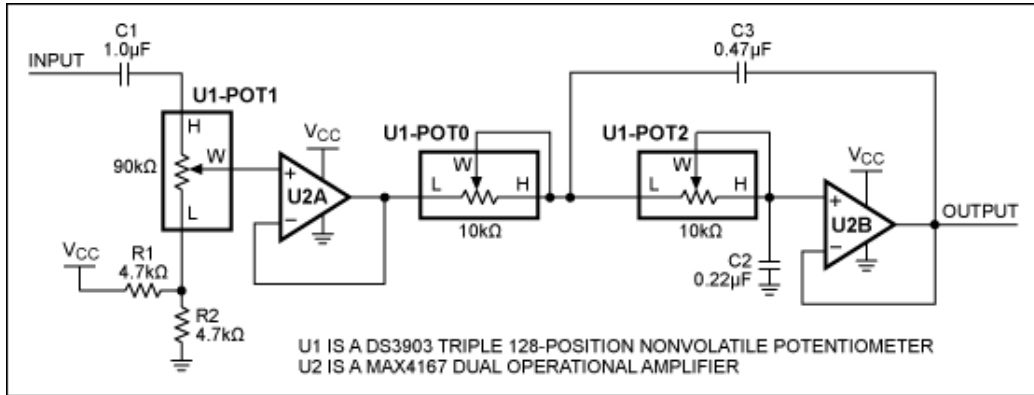


See application note 3990, "Current-Source DAC with PIN Diode Provides RF Attenuation and Thermal Compensation."



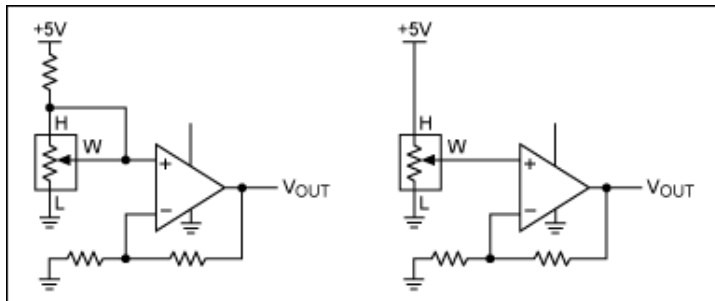
See application note 647, "Comparator/DAC Combinations Solve Data-Acquisition Problems."

Filter

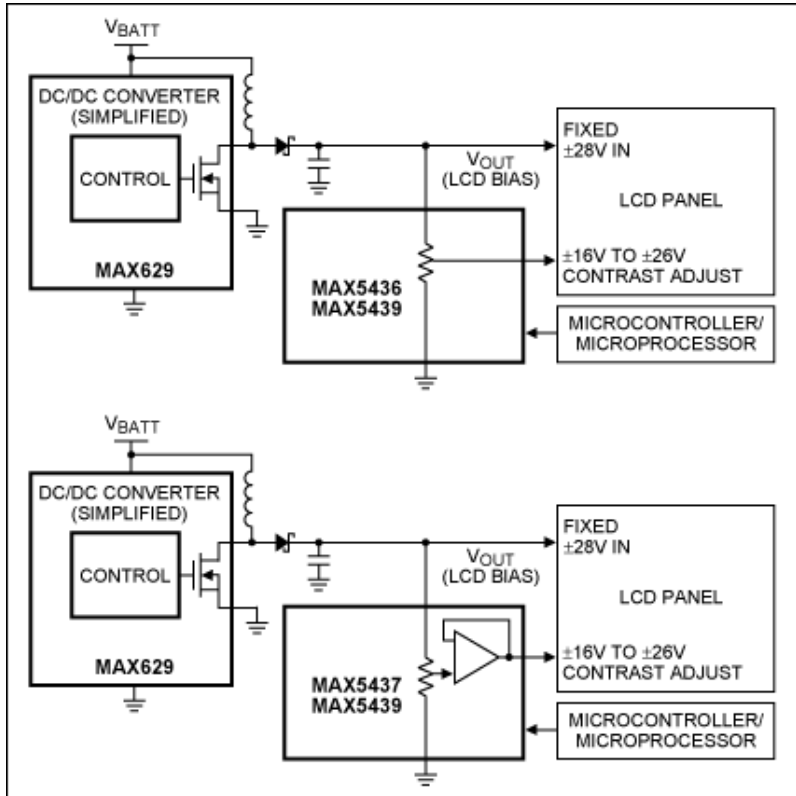


See application note 3077, "A Digitally Controllable Lowpass Filter Using a Digital Potentiometer."

LCD Bias

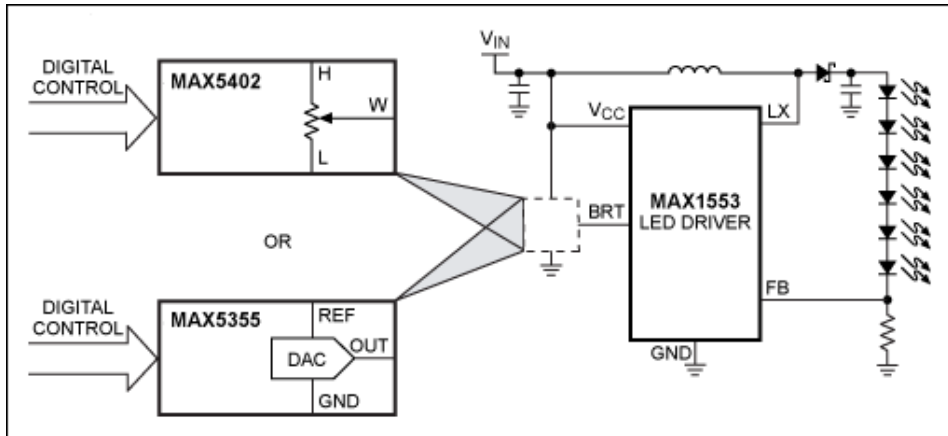


See the [MAX5389 data sheet](#).

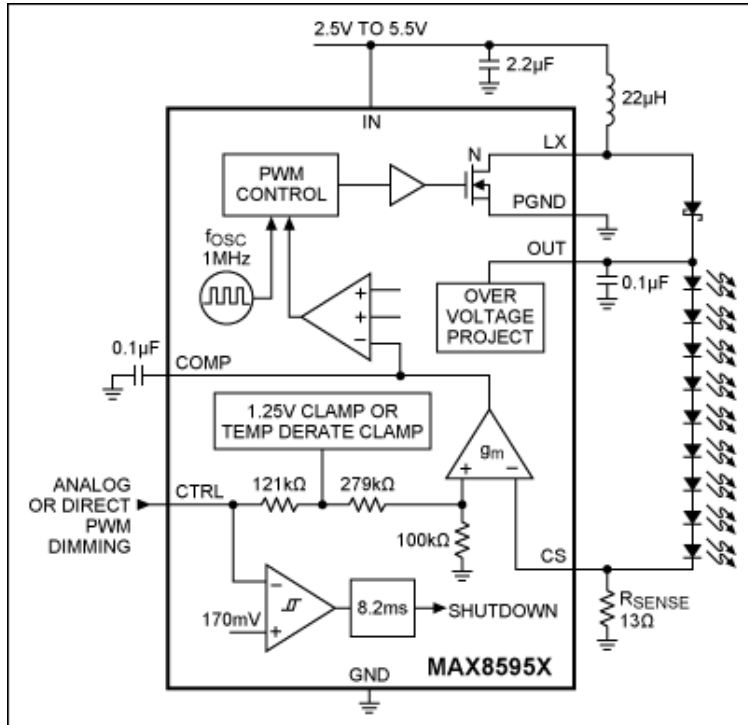


See the [MAX5436 data sheet](#).

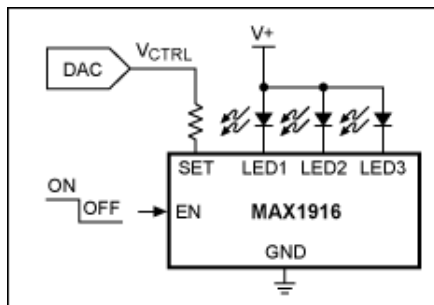
LED



See application note 4025, "DACs vs. Digital Potentiometers: Which Is Right for My Application?"

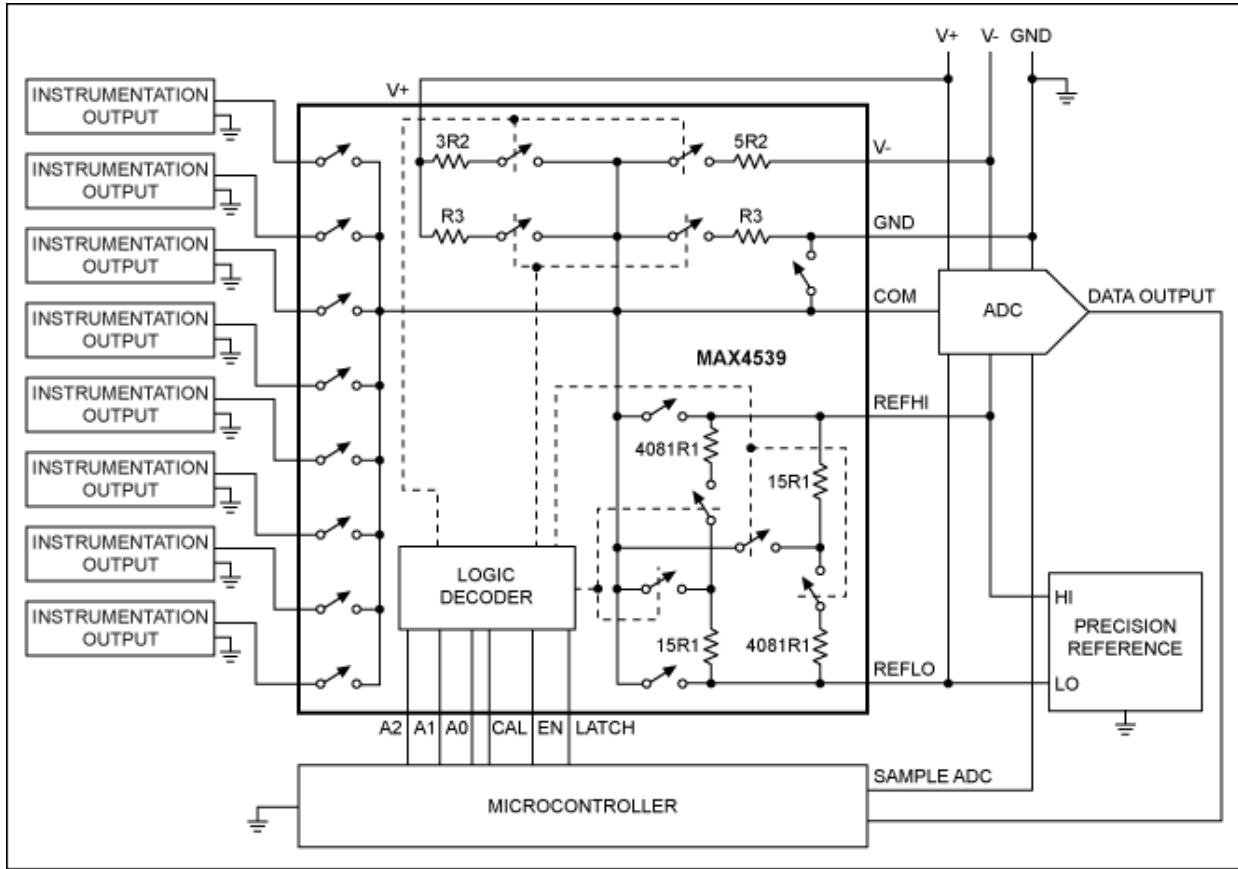


See the [MAX8595 data sheet](#).



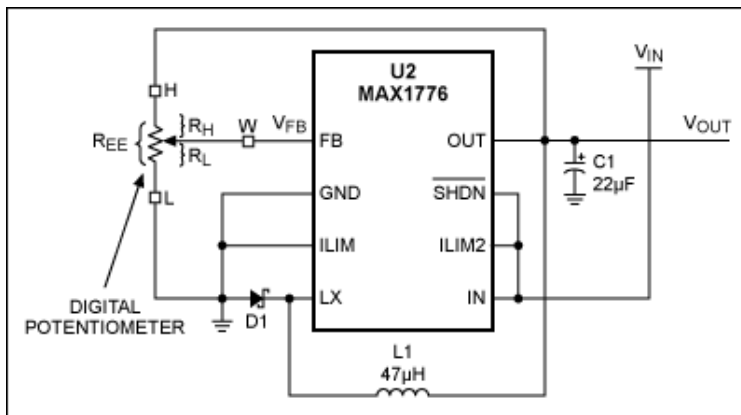
See application note 1037, "Charge-Pump and Step-Up DC-DC Converter Solutions for Powering White LEDs in Series or Parallel Connections."

Multiplexer

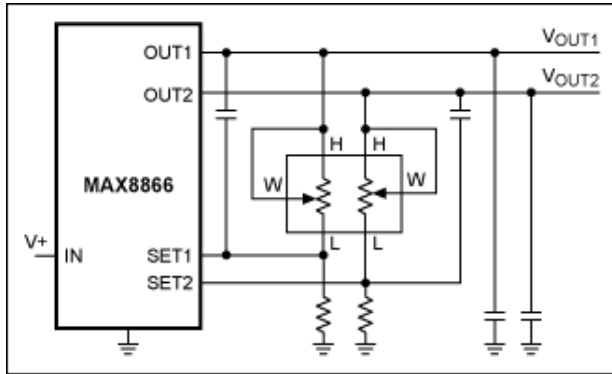


See application note 261, "Calibration-Multiplexers Ease System Calibration."

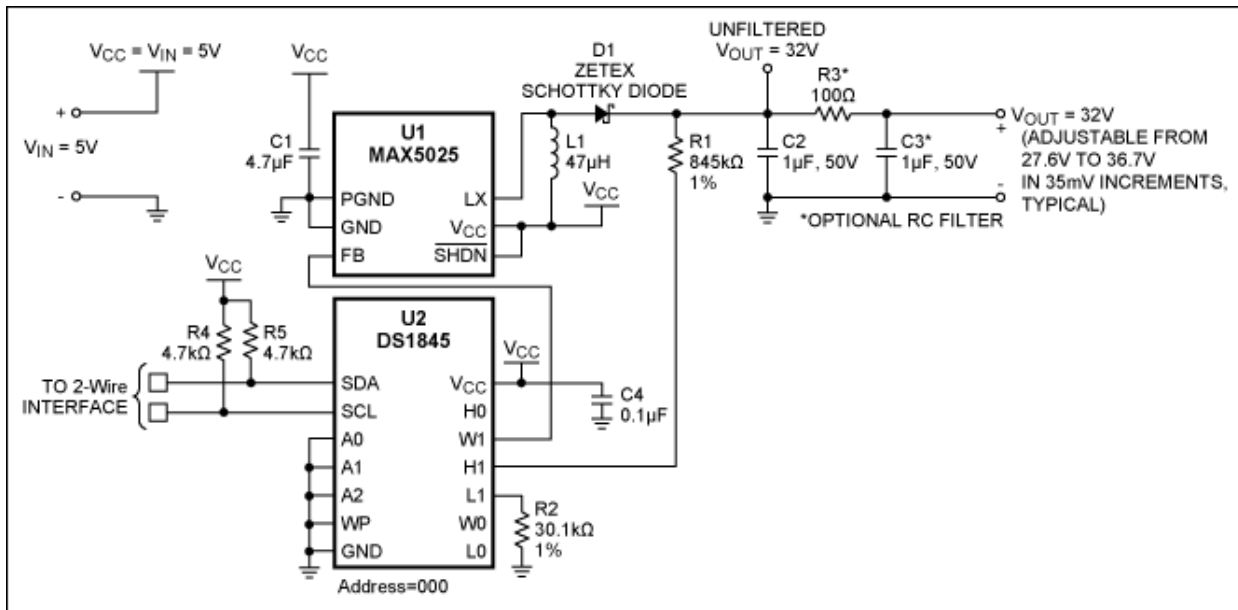
Power Supplies



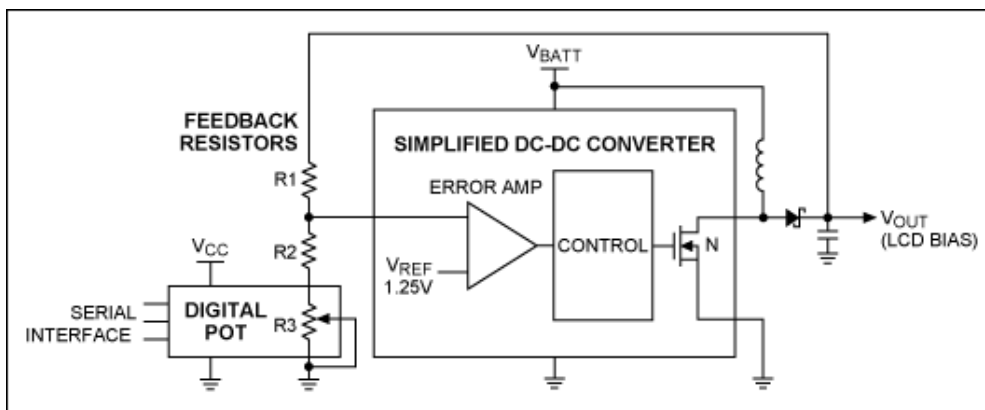
See application note 225, "Using Digital Potentiometers in Adjustable Step-Down DC-DC Converter Designs."



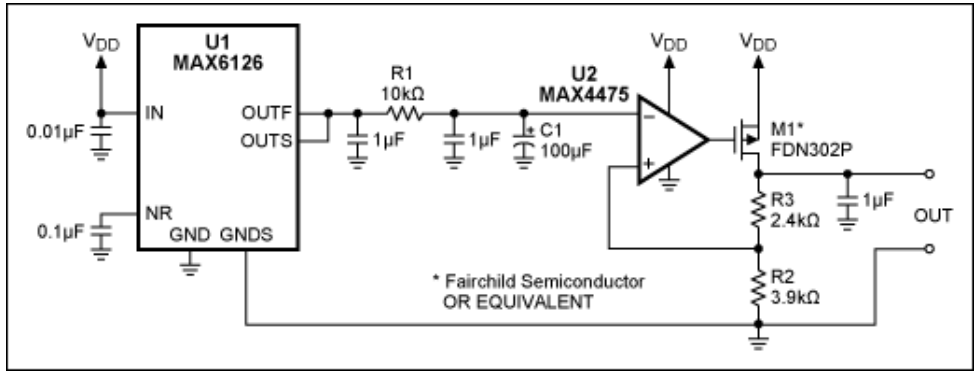
See the [MAX5389 data sheet](#).



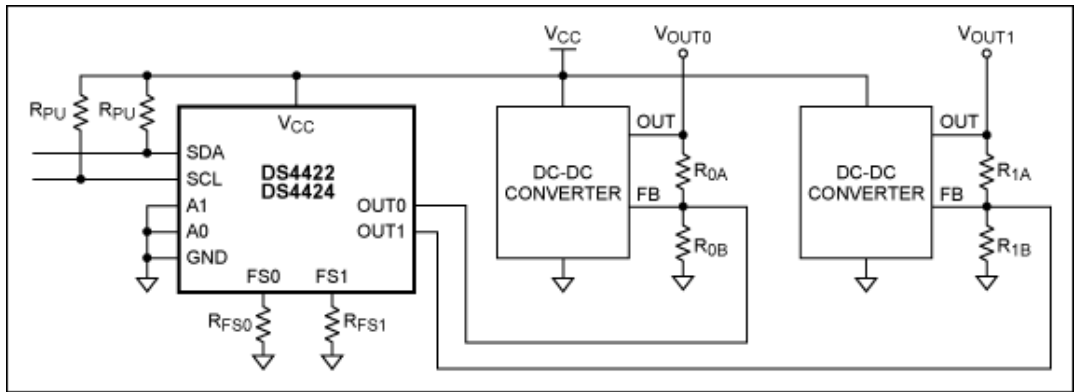
See application note 226, "Step-Up DC-DC Converter Calibration and Adjustment Using a Digital Potentiometer."



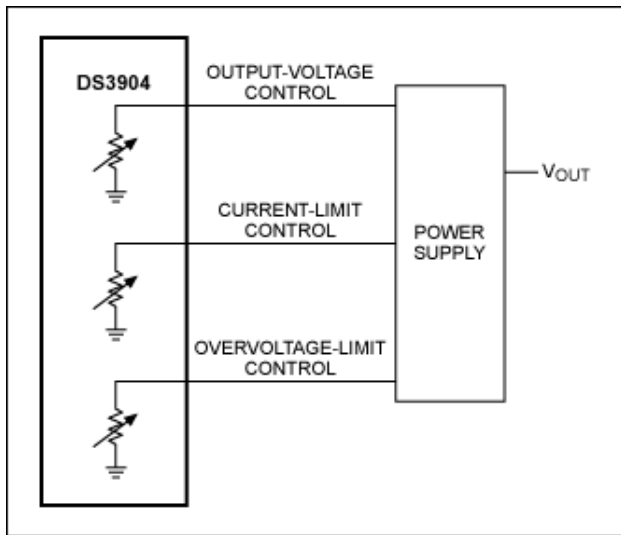
See application note 818, "Digital Adjustment of DC-DC Converter Output Voltage in Portable Applications."



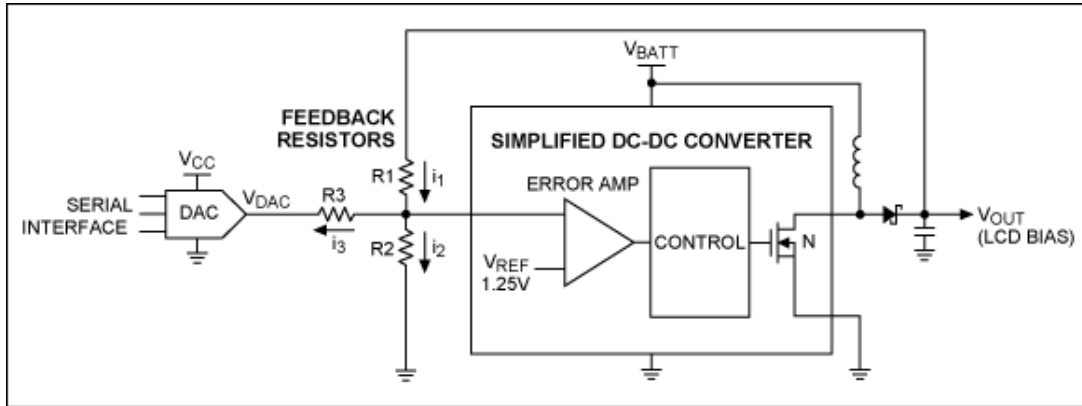
See application note 3657, "[Ultra-Low-Noise LDO Achieves 6nV/√Hz Noise Performance.](#)"



See the [DS4422 data sheet](#).

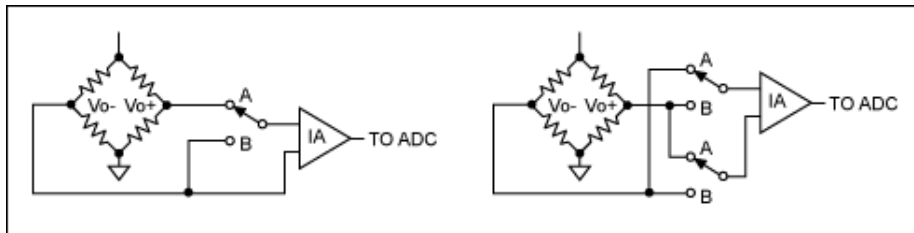


See application note 4101, "[Differentiating Digital Potentiometer Features.](#)"

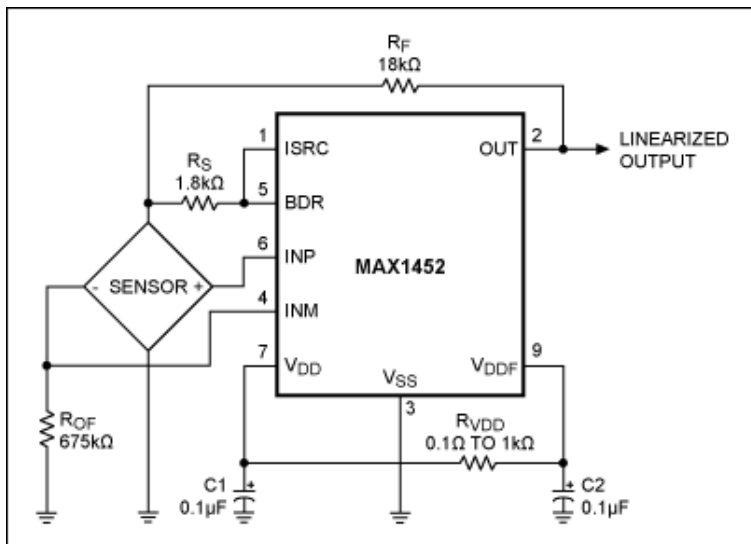


See application note 818, "[Digital Adjustment of DC-DC Converter Output Voltage in Portable Applications.](#)"

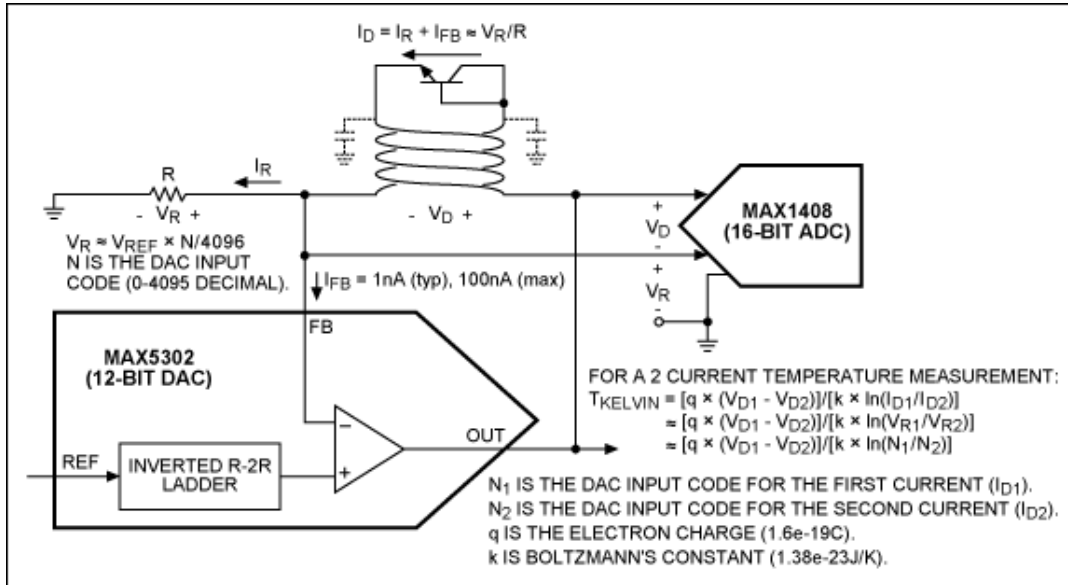
Sensor Support



See application note 3426, "[Resistive Bridge Basics: Part One.](#)"

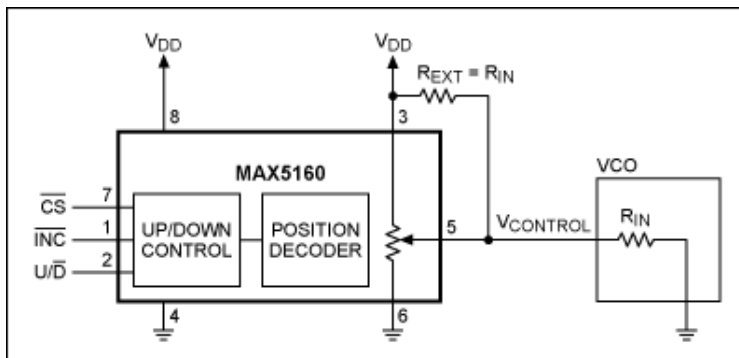


See application note 4022, "[MAX1452 Nonlinearity-Correction Application Circuit.](#)"

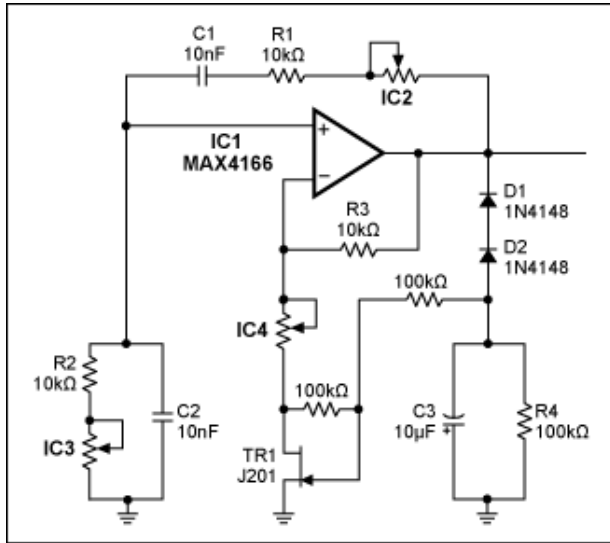


See application note 807, "Force/Sense DAC Applications."

VCO

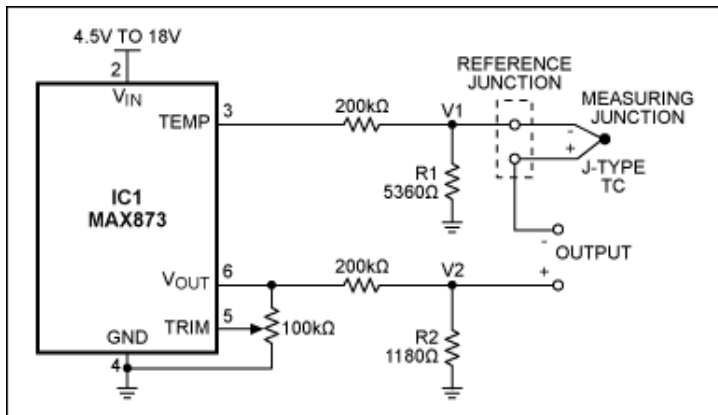


See application note 2095, "External Resistor Minimizes Digipot Loading."

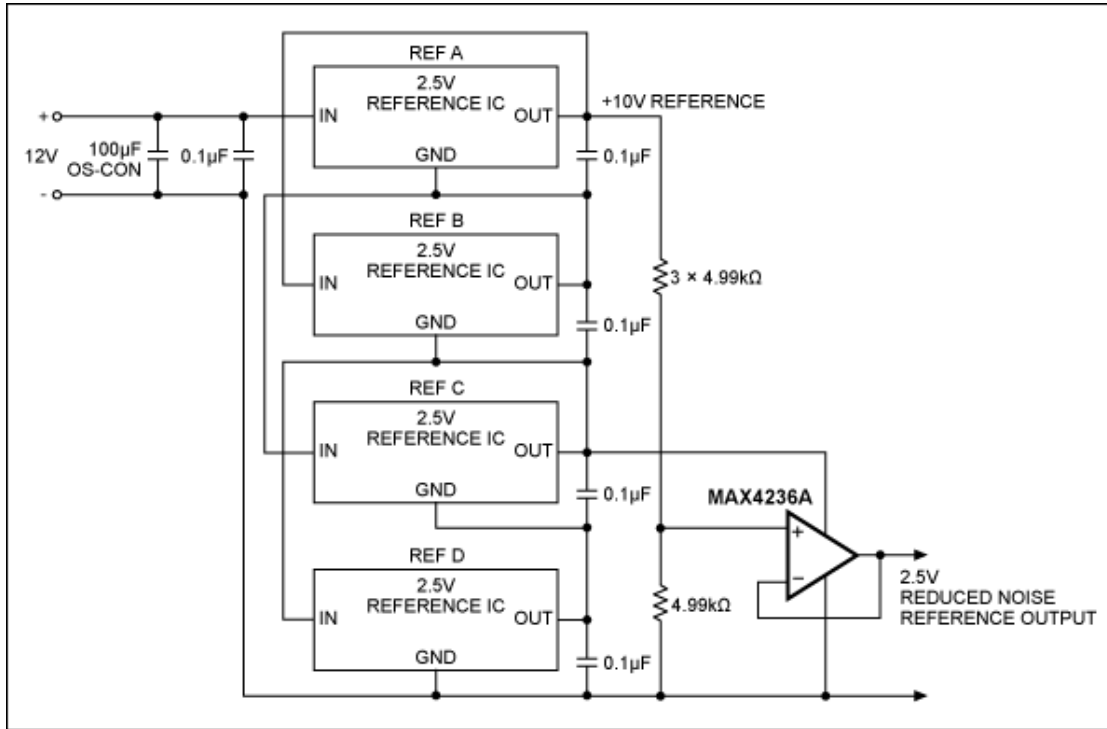


See application note 3846, "Analysis of a Digitally Controlled Wien-Bridge Oscillator."

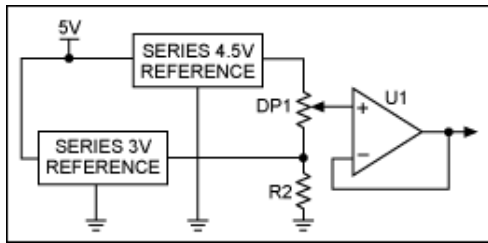
Voltage Reference



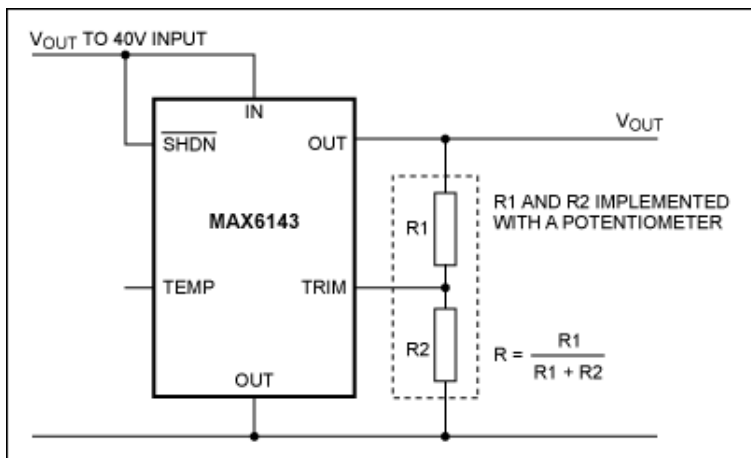
See application note 430, "Voltage Reference Compensates Reference Junction."



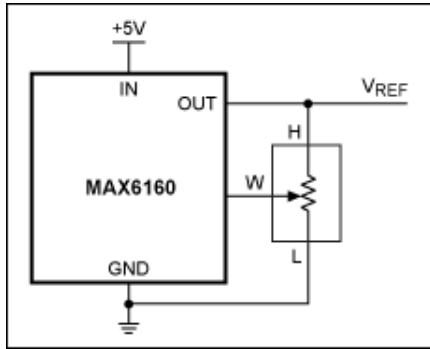
See application note 3531, "How to Reduce Reference Noise by Half."



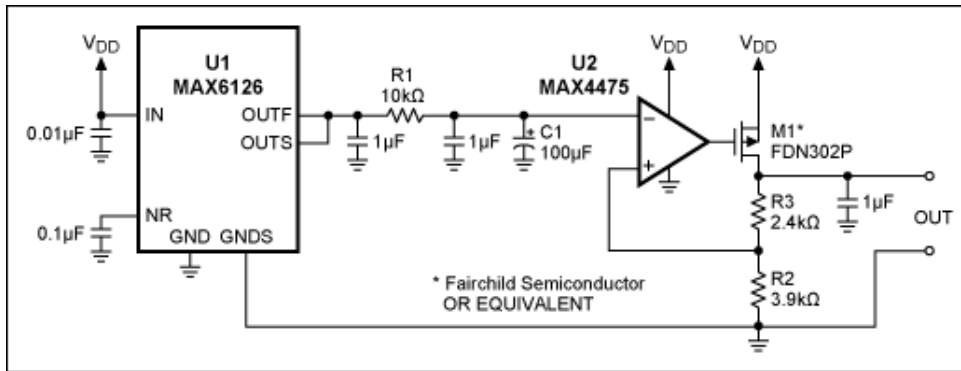
See application note 4290, "Ratiometric Design Overcomes the 25% Tolerance of a Digital Potentiometer."



See application note 4494, "Methods for Calibrating Gain Error in Data-Converter Systems."



See the [MAX5389 data sheet](#).



See application note 3657, "[Ultra-Low-Noise LDO Achieves 6nV/ \$\sqrt{\text{Hz}}\$ Noise Performance.](#)"

Reference

- Application note 4711, "[Digital Calibration Makes Automated Test Easy; Calibration FAQs](#)"
- Application note 4704, "[Introduction to Electronic Calibration and Methods for Correcting Manufacturing Tolerances in Industrial Equipment designs](#)"
- Application note 4703, "[Introduction to Electronic Calibration and Methods for Correcting Manufacturing Tolerances in Medical Equipment Designs](#)"
- Application note 4300, "[Calculating the Error Budget in Precision Digital-to-Analog Converter \(DAC\) Applications](#)"
- Application note 4003, "[Series or Shunt Voltage Reference?](#)"
- Application note 226, "[Step-Up DC-DC Converter Calibration and Adjustment Using a Digital Potentiometer](#)"

More calibration design tips and tools are available at www.maximintegrated.com/cal.

Related Parts

DS1841	Temperature-Controlled, NV, I ² C, Logarithmic Resistor	Free Samples
DS1881	Dual NV Audio Taper Digital Potentiometer	Free Samples
DS3906	Triple NV Low Step Size Variable Resistor Plus Memory	Free Samples
DS3930	Hex Nonvolatile Potentiometer with I/O and Memory	Free Samples
DS4422	Two-/Four-Channel, I ² C, 7-Bit Sink/Source Current DAC	Free Samples

MAX4539	Low-Voltage, Single 8 to 1 and Dual 4 to 1 Cal Multiplexers	Free Samples
MAX5331	12-Bit DACs with 32-Channel Sample-and-Hold Outputs	Free Samples
MAX5360	Low-Cost, Low-Power 6-Bit DACs with 2-Wire Serial Interface in SOT23 Package	Free Samples
MAX5380	Low-Cost, Low-Power, 8-Bit DACs with 2-Wire Serial Interface in SOT23	Free Samples
MAX5389	Dual, 256-Tap, Volatile, Low-Voltage Linear Taper Digital Potentiometer	Free Samples
MAX5427	32-Tap, One-Time Programmable, Linear-Taper Digital Potentiometers	Free Samples
MAX5436	±15V, 128-Tap, Low-Drift Digital Potentiometers	Free Samples
MAX5481	10-Bit, Nonvolatile, Linear-Taper Digital Potentiometers	Free Samples
MAX5592	Buffered, Fast-Settling, Octal, 12/10/8-Bit, Voltage-Output DACs	Free Samples
MAX5732	32-Channel, 16-Bit, Voltage-Output DACs with Serial Interface	Free Samples
MAX5774	32-Channel, 14-Bit, Voltage-Output DACs with Serial Interface	Free Samples
MAX6008A	1µA SOT23 Precision Shunt Voltage Reference	Free Samples
MAX6176	High-Precision Voltage References with Temperature Sensor	Free Samples

More Information

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Application Note 5036: <http://www.maximintegrated.com/an5036>

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