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Photovoltaic Bias Generator

by Arthur Harrison

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An adjustable voltage regulator that derives its input from a silicon photovoltaic cell, illuminated by LEDs, provides a galvanically isolated source for biasing an amplifier.

15. SUBJECT TERMS
voltage regulator, galvanic isolation, silicon cell, light-emitting diode, LED, bias voltage

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1. Introduction

System designs that require an isolated DC voltage source, such as low-current negative gate bias for amplifiers, often utilize a separate mains-connected power supply. This note proposes an alternative design that may reduce weight, volume, and cost, as well as provide improved galvanic isolation between the powered device and the input power source.

2. Circuit Description

The circuit in Fig. 1 converts a 12-V DC input into a regulated, adjustable voltage that may be set between 200 mV and 400 mV, developed for an application using gallium arsenide pseudomorphic high electron mobility transistor amplifiers that require an adjustable low-current negative potential for gate bias.

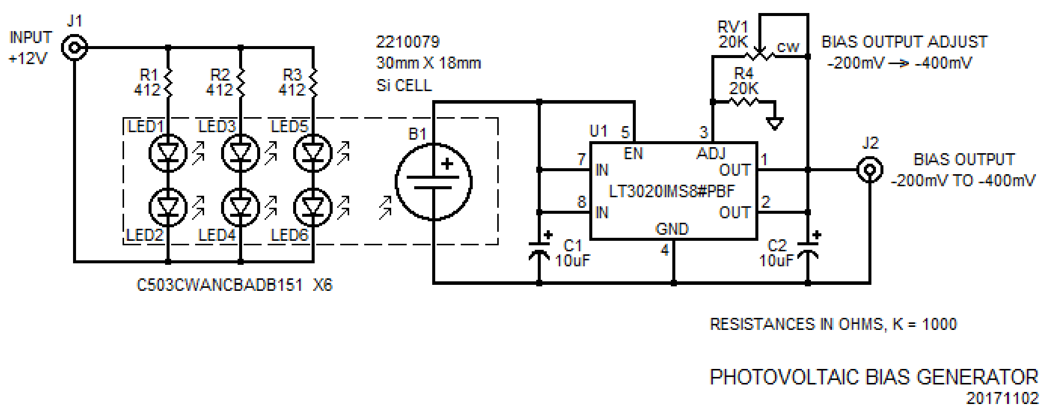

Fig. 1 Photovoltaic bias generator

The 12-V input current is 45 mA. The output is capable of supplying up to 2.5 mA at 400 mV, and 4 mA at 200 mV. While the circuit's 1% conversion efficiency is extremely low, its advantages include excellent galvanic isolation, achieved by photonic coupling between the LEDs and a silicon photovoltaic cell, and a complete absence of oscillators that would be utilized in other conversion techniques that use transformers or charge-pumped capacitors. The circuit is, therefore, excellent for applications where conducted or radiated noise from traditional conversion techniques cannot be tolerated. Also unique to the design is the complete isolation of load-current fluctuation from influencing the input. This characteristic may be especially useful where sensitive information processes must be well-isolated from the external environment.

Resistors R1, 2, and 3 set the operating current for LED 1 and 2, 3 and 4, and 5 and 6, respectively, at 15 mA per LED. This value was chosen to provide adequate illumination for the silicon photovoltaic cell (B1), while maintaining a conservative LED current to minimize heating and preserve LED life. The LEDs are evenly spaced in a 2 × 3 array within the periphery of the 18-mm-wide and 30-mm-long cell. The top of the LED domes are spaced about 0.2 inch from the cell.

Voltage regulation is achieved with integrated circuit U1, a Linear Technology type LT3020 low-voltage, very-low dropout regulator. This specialized regulator is especially unique in its ability to regulate inputs as little as 0.9 V.

Capacitors C1 and C2 provide circuit stability, and are selected per the manufacturer's recommendations. RV1 and R4 form an output voltage divider that drive U1's "ADJUST" pin to provide a range of output voltages between –200 mV and –400 mV. Since the output voltage is completely isolated from the input, it may be used in either polarity with respect to any other point in a system.

Figure 2 shows a prototype version of the circuit, enclosed in a small metal box with female SMA connectors for the INPUT and BIAS OUTPUT. The RV1 BIAS OUTPUT ADJUST potentiometer is top mounted to provide ease of adjustment. The components are mounted on perforated glass-epoxy board with wrapped-wire terminals, as shown in Fig. 3 and Fig. 4.

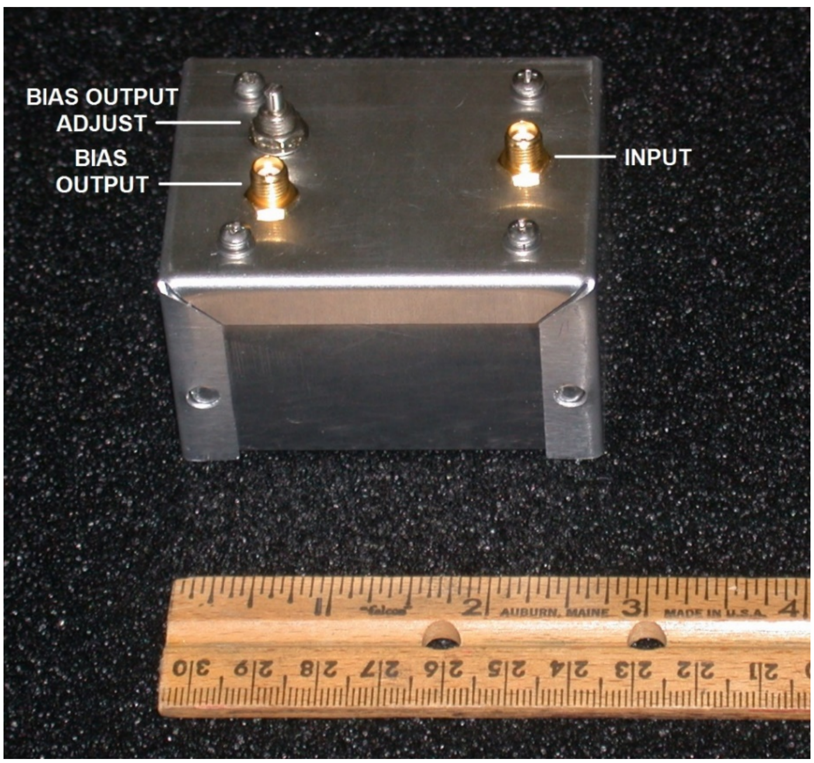

Fig. 2 Exterior view of the photovoltaic bias generator

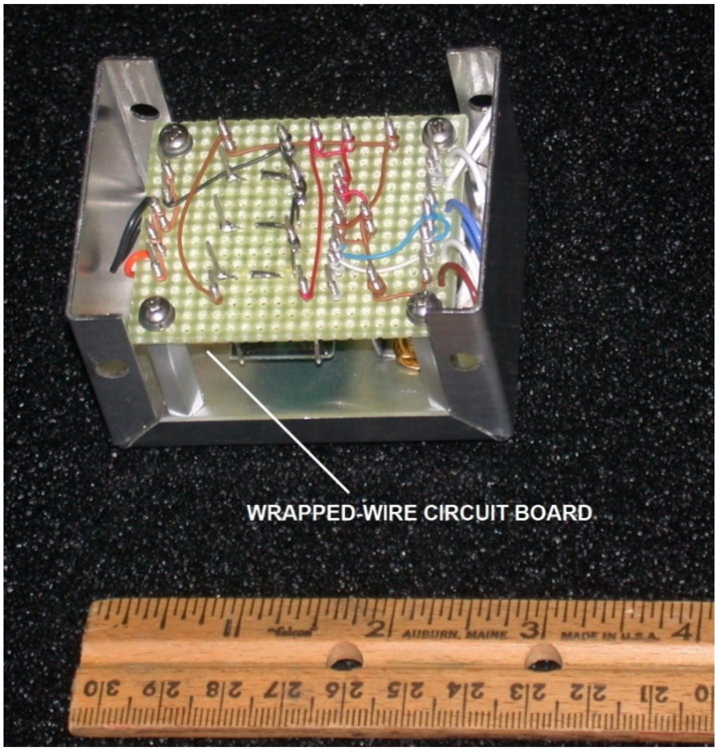

Fig. 3 Interior view of the photovoltaic bias generator showing wrapped-wire side of circuit board

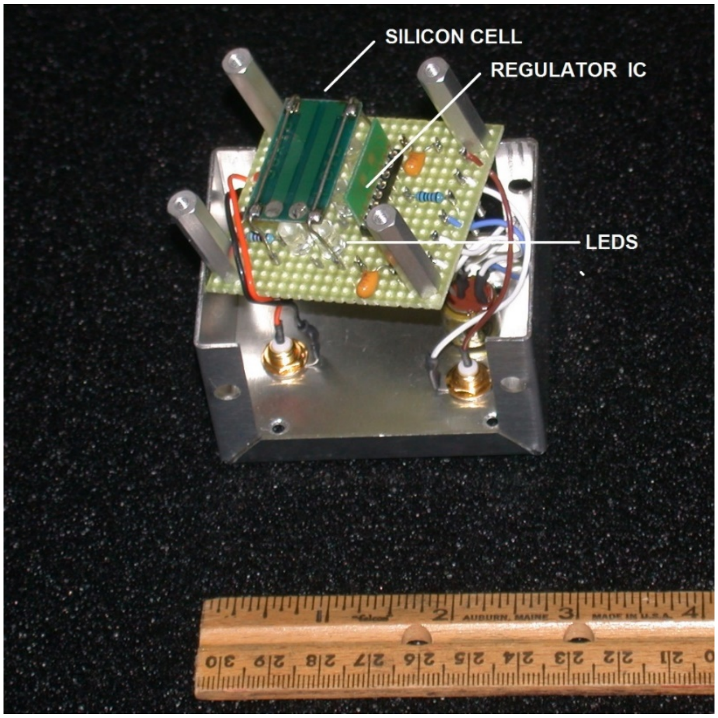

Fig. 4 Interior view of the photovoltaic bias generator showing component side of circuit board

3. Conclusion

An alternative to the traditional solution of a separate mains-connected power supply for systems requiring a galvanically isolated voltage source has been described. This alternative design provided a comparative reduction in weight, volume, and cost, as well as improved galvanic isolation between the powered device and the input power source.

List of Symbols, Abbreviations, and Acronyms

ARL	US Army Research Laboratory
DC	direct current
LED	light-emitting diode

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