Transimpedance Amp Employs Optically Isolated Digital Gain Control

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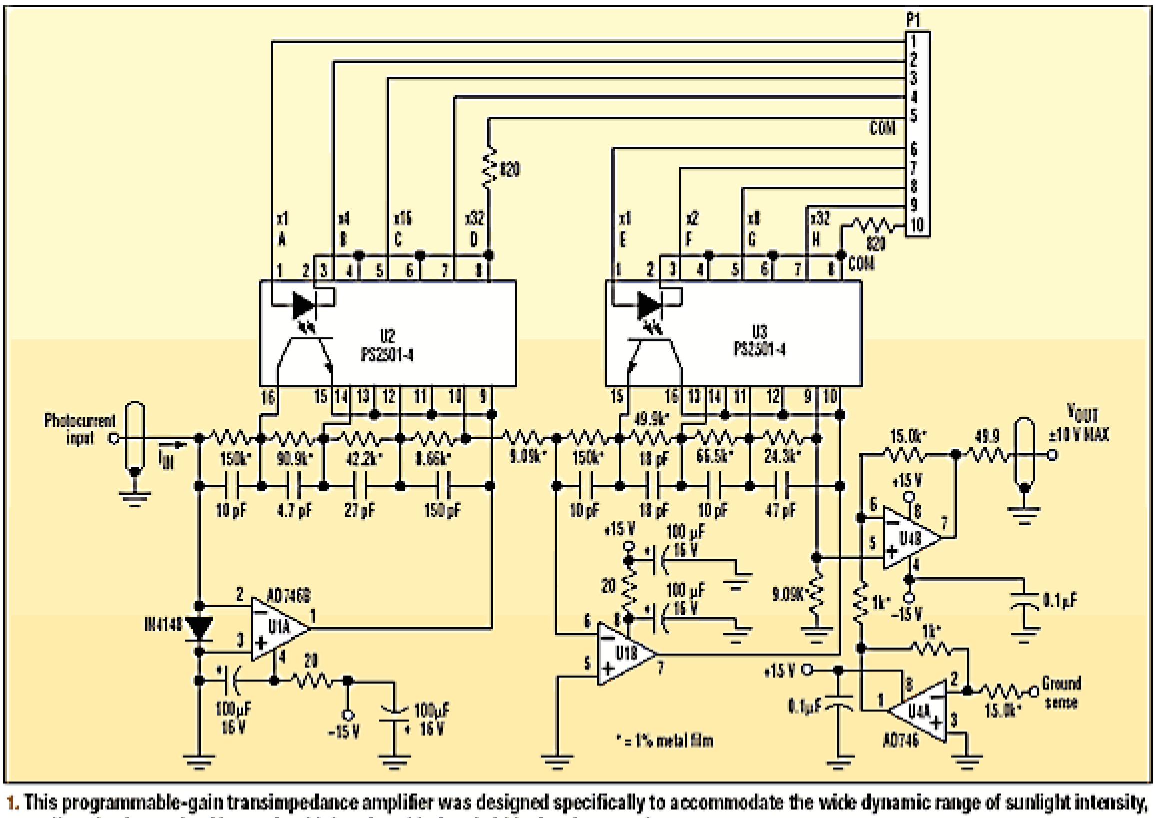
Located atop 7500-ft. Table Mountain near Wrightwood, Calif., is the Jet Propulsion Lab Fourier transform ultraviolet spectrometer (FTUVS). This device uses sunlight as a spectral light source for the chemical assay of trace gases, such as ozone and nitrogen oxides, in the Earth's atmosphere. At the business end of the FTUVS's optical system, which collects sunlight for spectral analysis, is a large-area avalanche photodiode. Its output signal is ultimately digitized by a high-speed 16-bit analog-todigital converter (ADC).

Conversion of the photodiode output current to an ADC input voltage is performed by a programmable-gain transimpedance amplifier (Fig. 1).



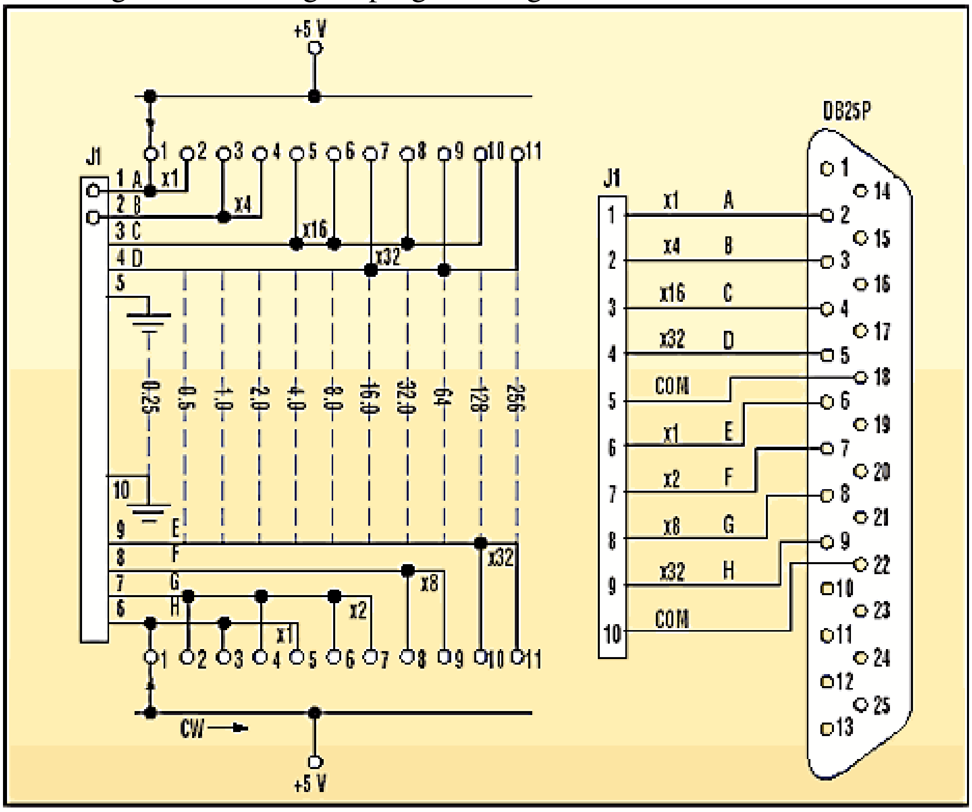
1. This programmable-gain transimpedance amplifier was designed specifically to accommodate the wide dynamic range of sunlight intensity, as well as the demands of low-noise, high-gain, wide-bandwidth signal processing.

This amplifier was designed to accommodate the wide dynamic range of sunlight intensity. It was also built to meet the demands of low-noise, high-gain, wide-bandwidth signal processing and transmission in a noisy digital environment. The transimpedance amplifier is implemented in three main functional blocks (Fig. 1, again). One of these is a digitally controlled photocurrent amplifier (U1A) with a digitally settable current gain of 1, 4, 16, or 32. Another is a current-to-voltage converter (U1B) with a selectable transimpedance gain of 1, 2, 8, or 32 times 150 kÙ. Also included is a fixed gain-of-16 differentialoutput voltage-gain stage (U4B). It has a 50-Ù output impedance and ±40-dB ground-loop noise rejection via a remote (optional) ground sense (U4A).

This circuit features an unusual design. It uses phototransistor optocouplers as isolated digital gain-switch elements in the op-amp feedback networks. Normally the large on-state voltage offset (tens to hundreds of millivolts) of bipolar phototransistors would preclude their application in a precision analog circuit such as this. But the transimpedance amplifier employs a peculiar feedback topology that places the gain switches inside the gain-stage feedback loop. Any offset introduced by the switches is then canceled by op-amp closed-loop gain. Therefore, it doesn't affect the amplifier's overall accuracy.

Amplifier transimpedance gain is programmed via an optically isolated 8-bit control word. This control word is organized as two 1-of-4 input codes, labeled ABCD and EFGH (to see the table, click on the IFD icon at www.elecdesign.com).

The gain-change settling time is approximately 100 µs. Bandwidth for all gain settings is greater than 100 kHz. The gain programming word can be generated by a 2-pole, 11-position rotary switch, such as Mouser catalog number 10WR122, for manual amplifier control. This also can be accomplished by using any TTL-compatible 8-bit parallel digital computer I/O port (e.g., any "IBM PC parallel printer port" or an EIA-1284 compatible port) for automated control. Figure 2 illustrates the appropriate wiring for two such gain-programming sources.



2. For control of transimpedance gain, the appropriate wiring for controlling the gain-setting optocouplers for both manual (left) and automated (right) control is shown.