

Flasher Powered by Photovoltaic Cells and Ultracapacitors

Characteristics include reliability, long life, and wide temperature range.

John H. Glenn Research Center, Cleveland, Ohio

A unique safety flasher powered by photovoltaic cells and ultracapacitors has been developed. Safety flashers are used wherever there are needs to mark actually or potentially hazardous locations. Examples of such locations include construction sites, highway work sites, and locations of hazardous operations.

Heretofore, safety flashers have been powered by batteries, the use of which entails several disadvantages: Batteries must be kept adequately charged, and must not be allowed to become completely discharged. Batteries have rather short cycle lives, and their internal constituents that react chemically to generate electricity deteriorate (and hence power-generating capacities decrease) over time. The performances of batteries are very poor at low temperatures, which often occur in the circumstances in which safety flashers are most needed. The disposal of batteries poses a threat to the environment. The development of the present photovoltaic/ultracapacitor-powered safety flasher, in which the ultracapacitors are used to

store energy, overcomes the aforementioned disadvantages of using batteries to store energy.

The ultracapacitors in this flasher are electrochemical units that have extremely high volumetric capacitances because they contain large-surface-area electrodes separated by very small gaps. Ultracapacitors have extremely long cycle lives, as compared to batteries; consequently, it will never be necessary to replace the ultracapacitors in the safety flasher. The reliability of the flasher is correspondingly increased, and the life-of-system cost and the adverse environmental effects of the flasher are correspondingly reduced. Moreover, ultracapacitors have excellent low-temperature characteristics, are maintenance-free, and provide consistent performance over time.

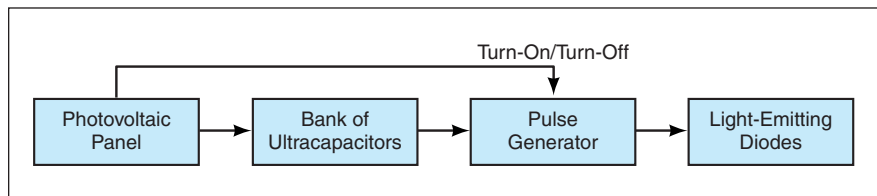
The flasher circuit (see figure) includes a 3-volt, 50-milliamper, all-weather photovoltaic panel connected in parallel with two 100-farad ultracapacitors, and with a pulse generator. The ultracapacitors can store enough

energy to sustain operation of the flasher for as long as 30 hours. Ultracapacitors are excellent for this application in that a complex voltage regulator is not required, as would be the case if batteries were used. The pulse generator puts out a pulse of 100-millisecond duration once per second. The pulses are fed to two high-efficiency light-emitting diodes. Light-emitting diodes are excellent for this application because they are characterized by low power demand, lack of inrush current, short response time, and long life. The light-emitting diodes are installed at the focus of a Fresnel lens to make them more visible from a distance. The voltage developed by the photovoltaic panel serves not only to charge the ultracapacitors but also as a signal to turn the pulse generator on at dusk and turn it off at dawn.

Because of the long lives of the photovoltaic panel, ultracapacitors, light-emitting diodes, and other electronic components, the minimum expected life of this flasher is 25 years.

This work was done by Dennis J. Eichenberg of Glenn Research Center and Richard F. Soltis of Indyne, Inc.

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The **Photovoltaic Panel** generates electrical energy that is stored in ultracapacitors. The stored energy is used to power the pulse generator, which causes the light-emitting diodes to flash.

Improved Autoassociative Neural Networks

These networks could learn relatively complex tasks.

NASA's Jet Propulsion Laboratory, Pasadena, California

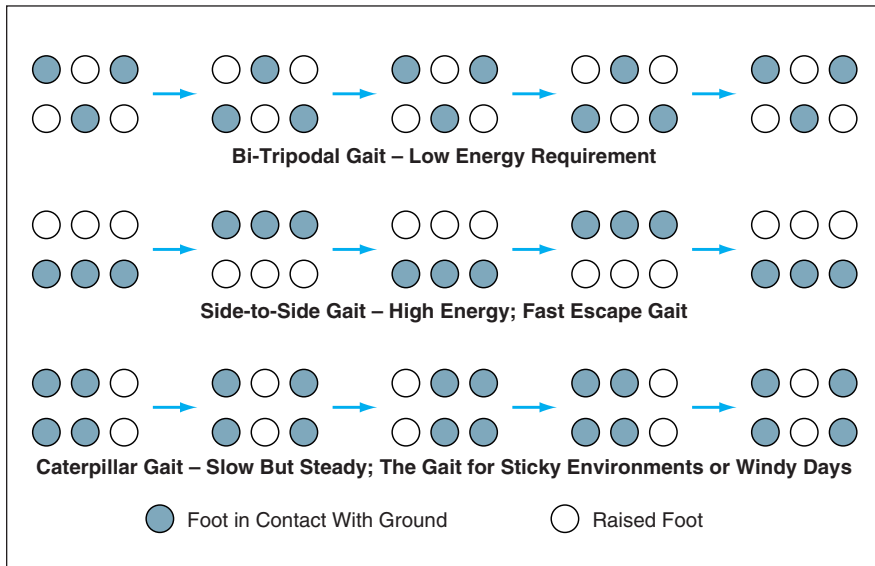
Improved autoassociative neural networks, denoted nexi, have been proposed for use in controlling autonomous robots, including mobile exploratory robots of the biomorphic type. In comparison with conventional autoassociative neural networks, nexi would be more complex but more capable in that they could be trained to do more complex tasks. A nexus would use bit weights and simple arithmetic in a manner that would enable training and operation without a central processing

unit, programs, weight registers, or large amounts of memory. Only a relatively small amount of memory (to hold the bit weights) and a simple logic application-specific integrated circuit would be needed.

A description of autoassociative neural networks is prerequisite to a meaningful description of a nexus. An autoassociative network is a set of neurons that are completely connected in the sense that each neuron receives input from, and sends output to, all the

other neurons. (In some instantiations, a neuron could also send output back to its own input terminal.) The state of a neuron is completely determined by the inner product of its inputs with weights associated with its input channel. Setting the weights sets the behavior of the network.

The neurons of an autoassociative network are usually regarded as comprising a row or vector. Time is a quantized phenomenon for most autoassociative networks in the sense that time proceeds in



These **Sequential Patterns of Raised and Lowered Feet** represent three basic gaits contemplated for locomotion of a hexapod robot. Each gait is best suited for a different circumstance or environment.

discrete steps. At each time step, the row of neurons forms a pattern: some neurons are firing, some are not. Hence, the current state of an autoassociative network can be described with a single binary vector. As time goes by, the network changes the vector. Autoassociative networks move vectors over hyperspace landscapes of possibilities.

The disadvantage of conventional autoassociative neural networks is that they are inefficient. The effect of training is to adjust the weights to values that are best for most patterns. At the end of training, all weights are fixed to reflect the majority of patterns. All the patterns that represent minorities (from the perspective of a single weight) are ignored. The performance of the network would be improved if the fixed weights were replaced with something more dynamic. This would be done in a nexus.

A nexus could be characterized as “deeper,” relative to a conventional autoassociative network, in that each weight of a conventional autoassociative network would be replaced by the output of a subnetwork. Whereas there are on the order of N^2 connections among N neurons in a conventional autoassociative network, the number of such connections in a nexus would be N^j ($j > 2$). In addition, the replacement of weights with subnetworks would introduce a capability for combining networks to form more complex networks.

A nexus would also differ from a conventional autoassociative neural network in the following ways:

- Synaptic subnetworks would be used throughout the network.
- Whereas a conventional autoassociative neural network changes all parts of

a vector, a nexus would change only the effector part.

- Whereas the weights of a conventional autoassociative neural network are numbers stored in registers, the weights of a nexus would be binary and could be stored as memory bits.
- The only arithmetic operations in a nexus would be majority votes of binary inputs.
- Learning by a nexus would be governed by a simple algorithm that would use both positive and negative examples. (Conventional autoassociative neural networks are usually trained by use of negative examples only.)

As an example of a potential application, nexi could be used to control the gaits of a walking hexapod robot. More specifically, a different nexus could learn one of three gaits (see figure) or a single nexus could learn all three gaits, albeit more slowly. Training could include positive feedback for forward progress and negative feedback for falling down.

This work was done by Charles Hand of NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

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Refer to NPO-21224, volume and number of this NASA Tech Briefs issue, and the page number.

Toroidal-Core Microinductors Biased by Permanent Magnets

Microinductors could be made smaller, saving space on integrated-circuit chips.

NASA's Jet Propulsion Laboratory, Pasadena, California

The designs of microscopic toroidal-core inductors in integrated circuits of DC-to-DC voltage converters would be modified, according to a proposal, by filling the gaps in the cores with permanent magnets that would apply bias fluxes (see figure). The magnitudes and polarities of the bias fluxes would be tailored to counteract the DC fluxes generated by the DC components of

the currents in the inductor windings, such that it would be possible to either reduce the sizes of the cores or increase the AC components of the currents in the cores without incurring adverse effects. Reducing the sizes of the cores could save significant amounts of space on integrated circuits because relative to other integrated-circuit components, microinductors occupy

large areas — of the order of a square millimeter each.

An important consideration in the design of such an inductor is preventing magnetic saturation of the core at current levels up to the maximum anticipated operating current. The requirement to prevent saturation, as well as other requirements and constraints upon the design of the core are ex-