

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).

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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.

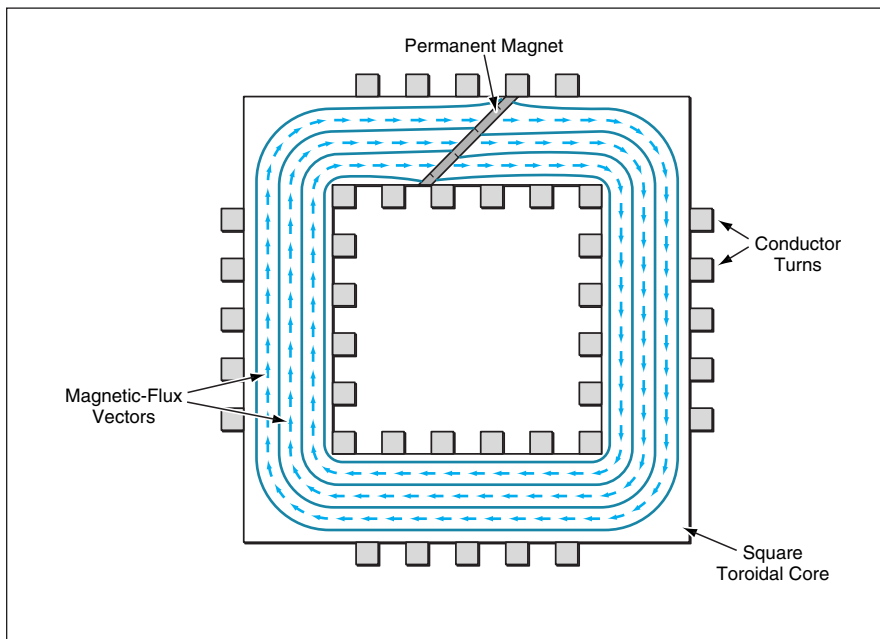
NASA's Jet Propulsion Laboratory, Pasadena, California

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-



A Permanent Magnet Would Be Placed in a Gap in the toroidal ferromagnetic core of a microinductor. Slanting of the gap as shown here is a design option that would make it possible to use a larger permanent magnet to increase the permanent magnetic flux, without incurring a need for pole pieces to concentrate the permanent magnetic flux into the core.

pressed by several equations based on the traditional magnetic-circuit approximation. The equations involve the core and gap dimensions and the magnetic-property parameters of the core and magnet materials.

The equations show that, other things remaining equal, as the maximum cur-

rent is increased, one must increase the size of the core to prevent the flux density from rising to the saturation level. By using a permanent bias flux to oppose the flux generated by the DC component of the current, one would reduce the net DC component of flux in the core, making it possible to reduce the

core size needed to prevent the total flux density (sum of DC and AC components) from rising to the saturation level. Alternatively, one could take advantage of the reduction of the net DC component of flux by increasing the allowable AC component of flux and the corresponding AC component of current. In either case, permanent-magnet material and the slant (if any) and thickness of the gap must be chosen according to the equations to obtain the required bias flux.

In modifying the design of the inductor, one must ensure that the inductance is not altered. The simplest way to preserve the original value of inductance would be to leave the gap dimensions unchanged and fill the gap with a permanent-magnet material that, fortuitously, would produce just the required bias flux. A more generally applicable alternative would be to partly fill either the original gap or a slightly enlarged gap with a suitable permanent-magnet material (thereby leaving a small residual gap) so that the reluctance of the resulting magnetic circuit would yield the desired inductance.

This work was done by Udo Lieneweg and Brent Blaes of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-21102

Using Correlated Photons To Suppress Background Noise

Optical communication signals could be detected against very bright backgrounds.

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A proposed method of suppressing the effect of background noise in an optical communication system would exploit the transmission and reception of correlated photons at the receiver. The method would not afford any advantage in a system in which performance is limited by shot noise. However, if the performance of the system is limited by background noise (e.g., sunlight in the case of a free-space optical communication system or incoherently scattered in-band photons in the case of a fiber-optic communication system), then the proposed method could offer an advantage: the proposed method would make it possible to achieve a signal-to-noise ratio (S/N) significantly greater than that of an otherwise equivalent background-noise-limited optical communication system based on the classical trans-

mission and reception of uncorrelated photons.

The figure schematically depicts a classical optical-communication system and a system according to the proposed method. In the classical system, a modulated laser beam is transmitted along an optical path to a receiver, the optics of which include a narrow-band-pass filter that suppresses some of the background noise. A photodetector in the receiver detects the laser-beam and background photons, most or all of which are uncorrelated.

In the proposed system, correlated photons would be generated at the transmitter by making a modulated laser beam pass through a nonlinear parametric down-conversion crystal. The sum of frequencies of the correlated photons in

each pair would equal the frequency of the incident photon from which they were generated. As in the classical system, the correlated photons would travel along an optical path to a receiver, where they would be band-pass filtered and detected. Unlike in the classical system, the photodetector in the receiver in this system would be one that intrinsically favors the detection of pairs of correlated photons over the detection of uncorrelated photons. Even though there would be no way of knowing the precise location and time of creation of a given pair of correlated signal photons in the nonlinear down-conversion crystal, the fact that the photons are necessarily created at the same time and place makes it possible to utilize conventional geometrical imaging optics to reunite the photons in coinci-