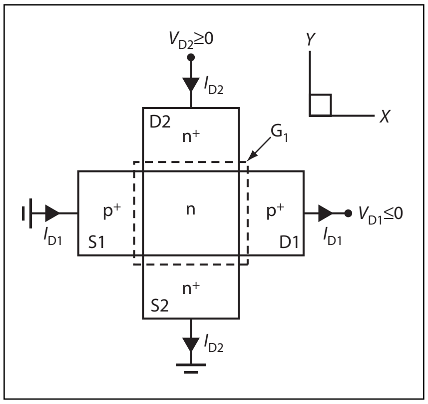

Figure 2. The **DC Configuration of the G[4]FET** of Figure 1 is helpful in understanding the ability of the device to function as a router.

mode MOSFET in the orthogonal in-plane direction.

Figure 2 schematically shows the DC configuration of the G[4]FET relevant to its use as a signal router. The drain (D1) of the inversion-mode p-channel MOSFET is biased to V_{D1}, the drain (D2) of the accumulation-mode n-channel MOSFET is biased to V_{D2}, and the source terminals (S1 and S2) of both transistors are grounded. The two drain currents, I_{D1} and I_{D2}, are perpendicular to each other and can flow at the same time. I_{D1} depends on minority charge carriers and flows at the surface in the x direction, while I_{D2} depends on majority carriers and flows at the mid-depth of the silicon film in the y direction. Surface holes and bulk electrons do not recombine because front-gate-induced depletion region isolates them. The top gate can modulate both drain currents — I_{D1} through regular MOS action and I_{D2} through vertical-depletion-width modulation. I_{D1} and I_{D2} can also weakly modulate each other — an undesirable effect in that it results in some cross-talk. In operation of the G[4]FET as a router, S1 and S2 would be disconnected from ground and signals would be applied to D1 and D2 for the purpose of coupling them to S1 and S2, respectively. In experiments on a G[4]FET that had not been optimized for use as a router, square-wave signals of various frequencies from 1 kHz to 1 MHz were applied to D1 and D2 simultaneously and were shown to be coupled to S1 and S2, respectively, as desired. Cross-talk was observed, but was found to be within conventional noise margins. This result supports the expectation that the integrity of digital signals could be preserved when using G[4]FETs as routers.

This work was done by Amir Fijany, Farrokh Vatan, Mohammad Mojarradi, Nikzad Toomarian, Travis Johnson, Elizabeth Kolawa, Benjamin Blalock, Sorin Cristoloveanu, Suheng Chen, and Kerem Akarvardar of Caltech for NASA's Jet Propulsion Laboratory.

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Two Algorithms for Processing Electronic Nose Data

Vapors are identified and their concentrations are estimated.

John F. Kennedy Space Center, Florida

Two algorithms for processing the digitized readings of electronic noses, and computer programs to implement the algorithms, have been devised in a continuing effort to increase the utility of electronic noses as means of identifying airborne compounds and measuring their concentrations. One algorithm identifies the two vapors in a two-vapor mixture and estimates the concentration of each vapor (in principle, this algorithm could be extended to more than two vapors). The other algorithm identifies a single vapor and estimates its concentration.

An electronic nose consists of an array of sensors, all of which respond to a variety of chemicals. By design, each sensor is unique in its responses to these chemicals: some or all of the sensitivities of a given sensor to the various vapors differ from the corresponding sensitivities of another sensor. The two algorithms exploit these sensitivities and the differences among them.

The validity of the two-vapor algorithm depends on the validity of the assumption that, of all the vapors of interest, no more than two of them are present at the time of measurement. This algorithm utilizes the following mathematical model of the response of a given sensor to a given pair of vapors:

$$z = A + (Bx^C + Dy^E)^F,$$

where z is the sensor response, x and y are the concentrations of the two vapors, and parameters A through F are obtained by least-squares best fit of sensor responses to known concentrations of the individual vapors and to known concentrations of mixtures of the two vapors. The reason for choosing this model is that this research has shown it to be the best for mixtures of vapors. The model equation defines a response surface of the given sensor for the given pair of vapors.

Given the responses of an electronic nose to an unknown single vapor or two-vapor mixture, the first step of this algorithm is to calculate the difference between (1) the actual response of each sensor and (2) the model response of the sensor for an assumed pair of vapors. This calculation yields an error surface for the given sensor for the given two vapors. Next, the error surfaces thus calculated for all the sensors in the array are combined to obtain an error surface for the electronic nose with respect for the assumed two vapors. Next, the process as described thus far is performed for a different pair of vapors. The process is repeated until error surfaces for all possible pairs of vapors have been calculated.

It is necessary to find the minimum point on the electronic-nose error surface for each pair of vapors. In the present version of the algorithm, this is done by sampling values on a grid and selecting the sample that has the minimum value. In a subsequent enhanced version of the algorithm, a more sophisticated technique (e.g., gradient descent) might be used to find the minimum. The pair of vapors for which the electronic-nose error surface has the lowest minimum value is deemed to be identified as the vapor pair sensed by the electronic nose. Provided that this identification is correct, the concentrations of the two vapors are the coordinates of the location of the minimum on the error surface for that pair.

The validity of the single-vapor algorithm depends on the validity of the assumption that, of all the vapors of interest, only one is present at the time of measurement. This algorithm utilizes the following mathematical model of the response of a given sensor to a single vapor:

$$z = A(1 - e^{Bx}),$$

where z is the sensor response, x is the concentration of the vapor, and parameters A and B are obtained by least-squares best fit of sensor responses at known values of x. This model is appropriate because it gives both the expected zero response at zero concentration and saturation response at high concentration.

The first step of the single-vapor algorithm is to identify the vapor by applying standard statistical pattern-recognition techniques to the responses of the electronic nose. Assuming that the vapor has been correctly identified, one could, in principle, estimate the concentration by applying the inverse of the model to the responses of all sensors in the nose. The question is how best to utilize the readings of all the sensors in the nose to obtain the best estimate. Research has answered the question: the best estimate is obtained by inverting the reading of a single sensor known to be best for the vapor that has been identified. Accordingly, the algorithm chooses the sensor found to be best for the identified vapor and calculates the concentration from the reading of that sensor.

This work was done by Rebecca Young of Kennedy Space Center and Bruce Linnell and Barbara Peterson of ASRC Aerospace. Further information is contained in a TSP (see page 1).
KSC-12725/20

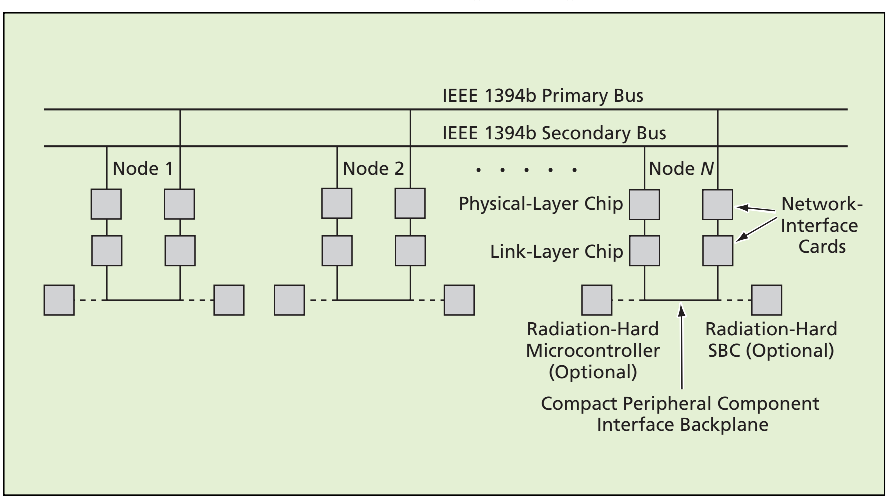
Radiation-Tolerant Dual Data Bus

Dedicated hardware and software would detect radiation-induced upsets on either of two buses.

Marshall Space Flight Center, Alabama

An architecture, and a method of utilizing the architecture, have been proposed to enable error-free operation of a data bus that includes, and is connected to, commercial off-the-shelf (COTS) circuits and components that are inherently susceptible to single-event upsets [SEUs (bit flips caused by impinging high-energy particles and photons)]. The architecture and method are applicable, more specifically, to data-bus circuitry based on the Institute for Electrical and Electronics Engineers (IEEE) 1394b standard for a high-speed serial bus.

The architecture and method call for the use of two IEEE 1394b buses that nominally carry identical data signals. It is assumed that at all times, at least one of the buses is "good" in the sense that it carries complete and correct data signals. Electronic hardware and software operating at each receiving location (node) along the bus would select the data arriving on the "good" bus while ignoring possibly corrupted data arriving on the other bus, which could be operating under latchup or an SEU including, possibly, a single-event functional interrupt (SEFI, an SEU that changes a control logic level, causing the affected circuit to enter an erroneous operational mode or logic state, the recovery from which must be effected through a power reset or other specified procedure).



Two IEEE 1394b Buses would nominally carry identical data signals. The network interface circumvention circuits, with the help of the microcontrollers, would detect radiation-induced upsets on either bus.

The hardware at each node would include network-interface circuits plus special-purpose circuits denoted circumvention circuits. Among the circumvention circuits would be bus-management circuits and watchdog timers that would monitor the network interface chips. Use of software would examine the outputs of these circumvention monitoring circuits to detect SEUs (including SEFIs). Latchups in radiation-sensitive IEEE 1394b bus components would be detected by current-sensing circumvention circuits. Upon detection of an SEU (including an SEFI) or latchup, other circumvention circuits would restore correct operation by turning off, then turning back on, then reinitializing the affected bus circuitry, all within a predetermined, acceptably short time.

The software would reside in a dedicated radiation-hard microcontroller or shared radiation-hard single-board computer (SBC).

This work was done by Gary A. Kinstler of The Boeing Co. for Marshall Space Flight Center.

Title to this invention has been waived under the provisions of the National Aeronautics and Space Act {42 U.S.C. 2457(f)} to The Boeing Co. Inquiries concerning licenses for its commercial development should be addressed to:

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