

determined amount of delay to any data signal that passes through this delay line. The delay line is programmed in degrees of offset, so that one could think of the clock period representing 360° of delay. In an ideal environment, delaying the strobe 1/4 of a clock cycle (90°) would place the strobe in the middle of the data packet. This delayed strobe can then be used to clock the data into a reg-

ister, satisfying setup and hold requirements of the system.

*This work was done by Michael Johnson, Dave Nelson, James Seefeldt, Weston Roper, and Craig Passow of Honeywell for Johnson Space Center. For further information, contact the JSC Innovation Partnerships Office at (281) 483-3809.*

*Title to this invention has been waived under the provisions of the National Aero-*

*navics and Space Act {42 U.S.C. 2457(f)}, to Honeywell. Inquiries concerning licenses for its commercial development should be addressed to:*

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*Refer to MSC-24931-1, volume and number of this NASA Tech Briefs issue, and the page number.*

## Using a Commercial Ethernet PHY Device in a Radiation Environment

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This work involved placing a commercial Ethernet PHY on its own power boundary, with limited current supply, and providing detection methods to determine when the device is not operating and when it needs either a reset or power-cycle. The device must be radiation-tested and free of destructive latch-up errors.

The commercial Ethernet PHY's own power boundary must be supplied by a current-limited power regulator that must have an enable (for power cycling), and its maximum power output must not exceed the PHY's input requirements, thus preventing damage to the device. A regulator with configurable output limits and short-circuit protection (such as the RHFL4913, rad

hard positive voltage regulator family) is ideal. This will prevent a catastrophic failure due to radiation (such as a short between the commercial device's power and ground) from taking down the board's main power.

Logic provided on the board will detect errors in the PHY. An FPGA (field-programmable gate array) with embedded Ethernet MAC (Media Access Control) will work well. The error detection includes monitoring the PHY's interrupt line, and the status of the Ethernet's switched power. When the PHY is determined to be non-functional, the logic device resets the PHY, which will often clear radiation induced errors. If this doesn't work, the logic device power-cycles the FPGA by toggling the

regulator's enable input. This should clear almost all radiation induced errors provided the device is not latched up.

*This work was done by Jeremy Parks, Michael Arani, and Roberto Arroyo of Honeywell Aerospace for Johnson Space Center. For further information, contact the JSC Innovation Partnerships Office at (281) 483-3809.*

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

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## Submerged AUV Charging Station

**Potential uses include studying ocean climate change, pollution, salinity, and currents.**

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Autonomous Underwater Vehicles (AUVs) are becoming increasingly important for military surveillance and mine detection. Most AUVs are battery powered and have limited lifetimes of a few days to a few weeks. This greatly limits the distance that AUVs can travel underwater. Using a series of submerged AUV charging stations, AUVs could travel a limited distance to the next charging station, recharge its batteries, and continue to the next charging station, thus traveling great distances in a relatively short time, similar to the Old West "Pony Express."

One solution is to use temperature differences at various depths in the

ocean to produce electricity, which is then stored in a submerged battery. It is preferred to have the upper buoy submerged a reasonable distance below the surface, so as not to be seen from above and not to be inadvertently destroyed by storms or ocean going vessels. In a previous invention, a phase change material (PCM) is melted (expanded) at warm temperatures, for example, 15 °C, and frozen (contracted) at cooler temperatures, for example, 8 °C.

Tubes containing the PCM, which could be paraffin such as pentadecane, would be inserted into a container filled with hydraulic oil. When the PCM is melted (expanded), it pushes the oil out

into a container that is pressurized to about 3,000 psi (≈20.7 MPa). When a valve is opened, the high-pressure oil passes through a hydraulic motor, which turns a generator and charges a battery. The low-pressure oil is finally reabsorbed into the PCM canister when the PCM tubes are frozen (contracted). Some of the electricity produced could be used to control an external bladder or a motor to the tether line, such that depth cycling is continued for a very long period of time.

Alternatively, after the electricity is generated by the hydraulic motor, the exiting low-pressure oil from the hydraulic motor could be vented directly