DESIGN ENVELOPE EVERCOOL

TECHNICAL OVERVIEW

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OVERVIEW

The Design Envelope EVERCOOL is a plant automation solution designed for the uptime and redundancy requirements of data centers. It takes a multi-tier approach to provide a robust fault-tolerant solution. The key elements of the redundancy features are described in the following.

HOT-STANDBY PLC'S

The control PLC operates in a hot-standby configuration. Two identical units operate (powered, receiving identical inputs, performing identical computations and producing identical outputs) in a master/hot-standby arrangement. Under normal operation, the master PLC controls the plant and is the only one allowed to write to any outputs. PLC data is continuously synchronized to ensure the same operating state between both the master and hot-standby. (This also allows for the live bring up of the hot-standby PLC when recovering from failures.)

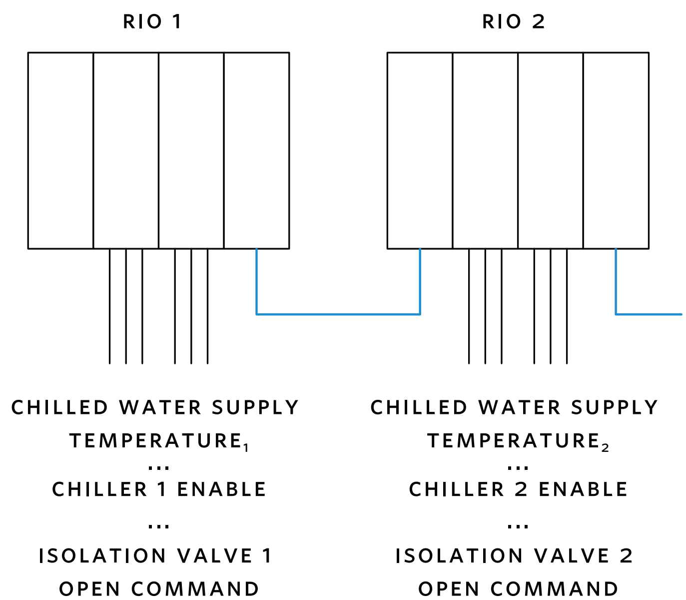
In the event of a master PLC failure (power or communication loss, hardware or software failure, etc.) a bumpless transfer (<300ms) occurs with the standby PLC assuming control of the outputs and the system. During this time, outputs are held, and downstream equipment and I/O are unaffected by the transfer.

INDEPENDENT DISTRIBUTED I/O MODULES (N+1 / 2N, ETC.)

Data centers require a significant quantity of redundant equipment, from mechanical equipment to sensors. The EVERCOOL matches this by having the equivalent number of **independent distributed I/O modules**. For a plant with N+1 (or other levels of redundancy) chillers, the EVERCOOL would have N+1 I/O modules. This modular approach allows for scalability in the quantity of equipment and the appropriate level of redundancy while minimizing complexity and eliminating the need for additional relays and wiring. Both the master PLC and standby PLC can communicate to all I/O modules at all times. This has the added benefit of allowing the EVERCOOL to control and optimize all available plant equipment without sacrificing redundancy.

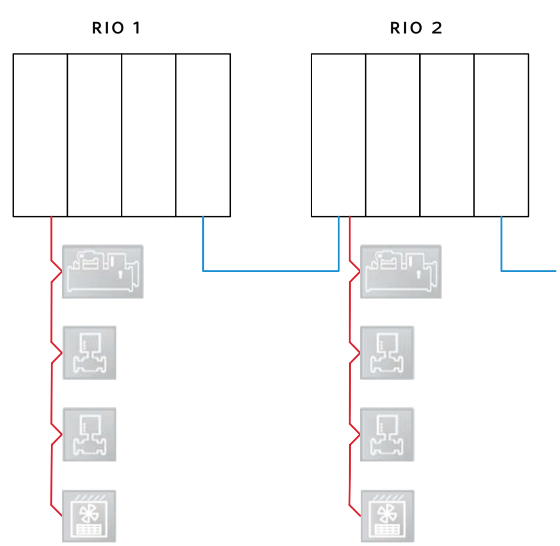
For digital and analog signals, such as pairs of redundant temperature sensors, each sensor is connected to different independent I/O modules as shown in **FIGURE 1**. Under normal operation, the value of both sensors is used. If the difference in the sensor values exceeds the tolerance, a notification is raised on the HMI. If one of the I/O modules fails, the other sensor input in unaffected and used. This setup is continued for each equipment set (pumps, chiller, cooling towers, isolation valves, etc.). The worst-case scenario from a single I/O module failure is the loss of a single set of mechanical equipment.

FIGURE 1: DISTRIBUTED I/O MODULE EXAMPLE



This distributed setup also applies to the serial communication network architecture as shown in **FIGURE 2**. A single communication trunk provides serial communication to 1 equipment set (chiller, pumps, cooling tower); minimizing the impact of any single serial network failure.

FIGURE 2: SERIAL COMMUNICATION ARCHITECTURE

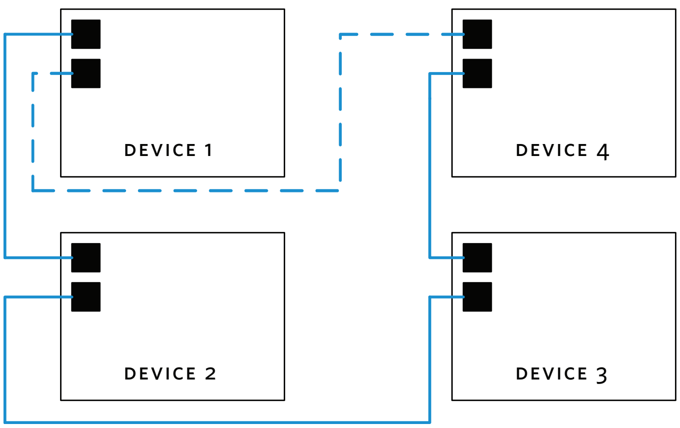


Optionally, remote equipment (pumps, chillers, cooling towers) can be controlled via hardwired I/O (start, run feedback, speed reference) with serial supervisory (read-only) or via serial communication control only.

RINGED NETWORK TOPOLOGY

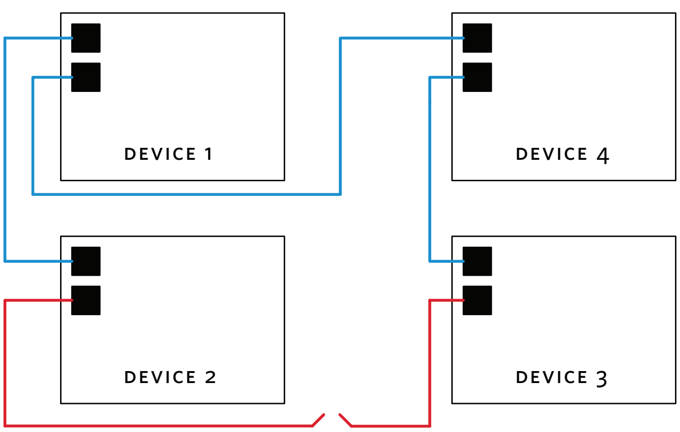
Communication between all critical control equipment is organized in a ring configuration.

FIGURE 3: NETWORK DURING NORMAL OPERATION (TRAFFIC DIRECTLY BETWEEN DEVICE 1 AND 4 IS BLOCKED)



During normal operation, one of the ports is blocked causing the network to operate in a linear topology (to prevent a network loop) as shown in **FIGURE 3**.

FIGURE 4: NETWORK AUTOMATICALLY RECOVERS FROM BREAK (IF A BREAK HAPPENS BETWEEN DEVICES 2 AND 3, THEN THE LINK BETWEEN DEVICE 1 AND 4 IS ACTIVATED)



In the event of break in any point in the network, the blocked port is activated re-completing the network as shown in **FIGURE 4**. This configuration is capable of handling single failures with a worst-case recovery time of 200 ms.

POWER REDUNDANCY

The EVERCOOL includes two full-sized parallel power supplies, per panel, that can each support that panel's electrical load as shown in **FIGURE 5**. This ensures the panel is unaffected by a fault in a single power supply. Each power supply can also be fed by separate dedicated power feeds from the building as shown in **FIGURE 6.**

FIGURE 5: REDUNDANT PARALLEL POWER SUPPLIES WITH SINGLE POWER FEED.

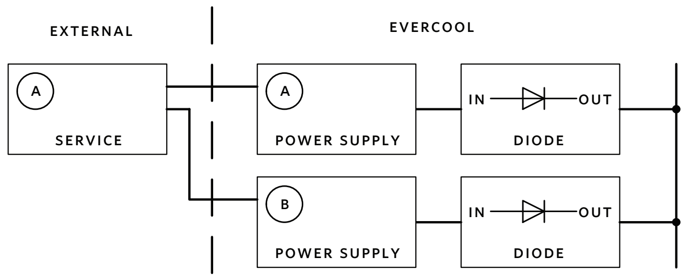
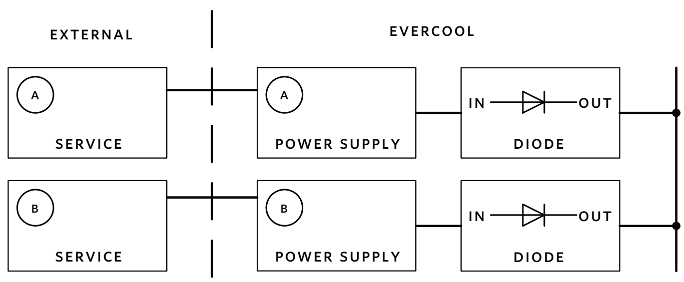


FIGURE 6: EVERCOOL SUPPLIED BY TWO SEPARATE DEDICATED BUILDING POWER FEEDS



The addition of UPS(s), adds protection against power fluctuations, outages and surges. Possible UPS configurations are shown in **FIGURES 7, 8** and **9**.

FIGURE 7: UPS WITH SINGLE POWER FEED

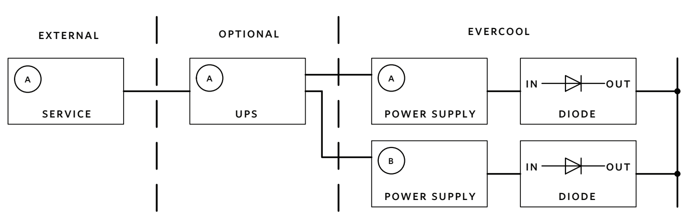


FIGURE 8: ALTERNATE UPS CONFIGURATION

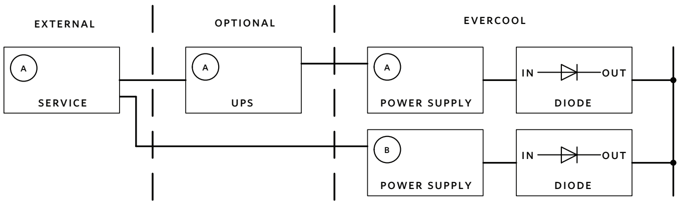
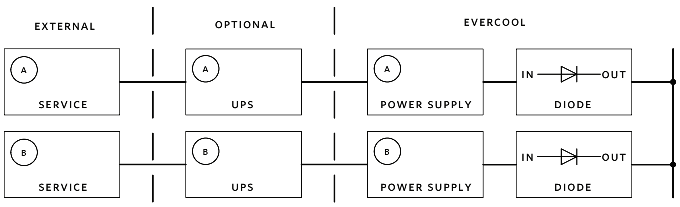


FIGURE 9: TWO SEPARATE DEDICATED BUILDING POWER FEEDS WITH TWO UPSS



INDUSTRIAL-AUTOMATION RATED HARDWARE

The above described architecture elements are mitigation strategies designed to handle potential failures. However, they don't define the reliability or failure rate of individual components. The EVERCOOL uses industrial-automation rated hardware for all crucial components. They feature extended and documented reliability over commercial HVAC[1] equipment in the areas of MTTF[2], immunity to EF[3] and ESD[4], vibration, shock, and temperature.

SEQUENCE OF OPERATIONS REDUNDANCY FEATURES

In addition to the hardware-based reliability features, there are additional software features to ensure the continued operation of the plant even in the event of equipment failures. Some of these features include:

- Ability to take multiple redundant sensor inputs
- Incident notification if redundant sensors report a difference in readings above a certain threshold
- If an entire set of sensors fail, the corresponding equipment has a fallback mode of operation
- In the event of loss of the flow sensor inputs the Sensorless™ flow can be used (if available)
- If equipment failures affect the plant capacity, other equipment sets will attempt to compensate for the capacity loss

NOTE:

1 HVAC: Heating, Ventilation and Air-Conditioning

2 MTTF: Mean time to failure

3 EF: Electromagnetic Fields

4 ESD: Electrostatic Discharge

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