Industrial Data Xchange
The Industrial Data Communications Experts

CASE STUDY:

Building a wireless freezer monitoring, alarming, and reporting solution at a biological sample storage facility

Solution: IDX Nexus IoT Hardware and IDX Suite Software used as a freezer monitoring system at a laboratory

Industry: Pharmaceutical and Biotechnological

Benefits:

- ✓ Suitable for all industries
- ✓ Resolve issues fast
- ✓ Manage alerts from anywhere
- ✓ Get in-depth visibility
- ✓ Suitable for all industries

Technology used:

- ✓ IDX Suite Software
- ✓ IDX Nexus Hardware

The IDX Suite is a multi-connector data software, allowing you to exchange real-time data between most protocols, devices, ERP systems, and commercial cloud service platforms.

IDX Nexus addresses the challenge of harvesting data that is tucked away in disparate systems or behind some little-understood communications protocols.

Real-time data monitoring, alarming and alerting for your entire infrastructure

There are numerous benefits to embracing the digitisation of systems and the use of real-time data monitoring, often associated with Internet of Things (IoT) and the Industry 4.0 revolution, ranging from the possibility of automated problem notification, automation of manual processes to the mining of the resulting data. Commercial and industrial customers are often keen to leverage these new technologies and have a general wish list of what they want to achieve but without having a clear vision of the solution or the potential challenges faced. Industrial Data Xchange (IDX) can assist by providing complete, industrial-grade hardware-to-user interface IoT solutions that ultimately address the customer's needs.

A customer that operates biological sample storage facilities in South Africa was seeking a monitoring, alarming and reporting solution for managing a facility containing approximately 100 ultra-low temperature Thermo-Fischer laboratory-class freezers.

The customer was seeking an integrated solution that could monitor the individual freezers as well as auxiliary facility equipment, show values in real-time, raise email/SMS alarms on critical events and record these values and events for reporting and auditability purposes.

Thermo-Fischer Laboratory-class freezers

In addition, the system required an “App”-type interface that would allow users to view the status of the devices being monitored from their mobile phones, when on-premises or remotely via their corporate intranet.

The system would also provide automated electronic reporting and maintenance operations previously done manually by lab technicians. A critical requirement of the solution was FDA-21 CFR Part II regulation compliance which has rigorous data control and auditability obligations.

Why was the IDX solution selected?

Given the scope of the requirements, IDX proposed a solution based on the IDX Suite server backend and IDX Nexus IoT hardware that provided all the end-to-end components required, that is, the real-time data collection hardware, a robust communication channel, server backend and a user- and device-friendly front end.

A customer prerequisite was that the freezer monitoring solution had to be wireless as the freezers are mounted on castor wheels and can be moved. Thus, a solution that does not add additional cables is simpler and keeps the facility neater and easier to re-organise when required.

The hardware that collected data from the mobile freezer units would collect specific freezer interface data, that included digital and analogue (4-20mA) inputs, and the freezer’s power consumption.

A custom, industrial-grade IDX Nexus hardware monitoring device was designed and manufactured specifically for the project. The hardware, centred around an ESP32 microprocessor, provided full freezer monitoring functionality, and included several notable features:

- A robust, splash-proof housing.
- All the digital and analogue inputs required to be monitored as well as a power pass-through connection allowing the Nexus to monitor the freezer power consumption.
- A super-capacitor backed power supply to prevent instantaneous device power and thus data loss.
- A data store-and-forward mechanism to ensure that a short- or long-term data communication loss with the server did not result in gaps in the historical data record.
- Over-the-air firmware update facility to allow new features, changes to operation and fixes to be deployed to all the devices from the central server.
- Secure, TLS-encrypted server communication.
- A magnetic maintenance switch, that allows lab personnel to indicate to the system that a freezer is undergoing extended maintenance and that alarms for that device should be temporarily suppressed.

Nexus unit mounted onto a freezer

A Nexus unit was mounted onto each freezer and was connected to monitor two temperatures (for redundancy), the freezer power consumption, the general alarm digital output, and the CO2 solenoid state.

The Nexus then establishes an encrypted MQTT data connection over Wi-Fi to the IDX server. It should be noted that the customer specifically opted for an on-premises server solution as opposed to a cloud-based backend - both of which were equally achievable given the solution architecture.

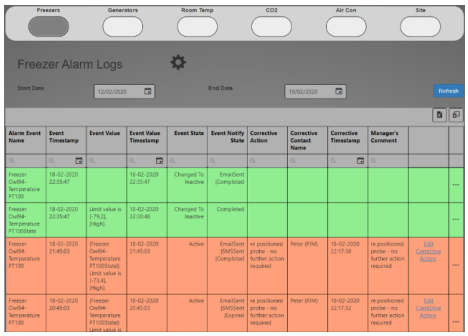
Additionally, auxiliary site items of interest were also monitored via fixed digital and analogue signal converters:

- The state of the site’s grid power supply.
- The state of the power input to the twelve site air conditioners.
- Four site temperature sensors.
- Three site CO2 sensors.

CO2 monitoring and site-local visualisation are critical. If, in the case of an extended power outage and generator failure, it is possible to supplement the cooling of the samples in the freezers using CO2 gas via an external solenoid connection to each freezer. However, leaks and the build-up of CO2 in the site could be hazardous to people, and thus needs to be monitored.

In terms of the solution's back end components, the IDX Suite server collects the data from all the Nexus units and makes the data generally available as real-time data in an OPC DA Server, but numerous other interfaces are also possible. This functionality was not explicitly used in this case except for ad-hoc monitoring but this functionality is especially useful for the integration of the collected IoT data with real-time industrial systems (an Ethernet/IP PLC for example), or even as overlay data on security video feeds for example.

The real-time data is also passed through the IDX Alarms and Events component that intelligently evaluates and raises alarms via SMS and email. The IDX Alarms and Events engine is specifically designed to prevent nuisance alarms and alarm floods, which usually desensitises users to all alarm notifications, which largely renders an alarming system ineffective.

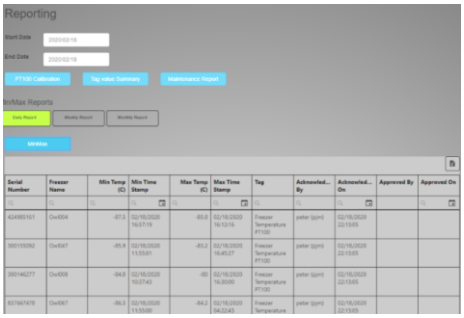


Example of Freezer Alarm Logs

In this customer's case, alarms were configured per device to trigger when the freezer temperature goes out of a defined range for an extended period of time, if there is an extended device communication issue, if the freezer loses power or if there is a site power failure.

Notably, the alarms are interlocked, for example, the trigger of the site power failure alarm prevents all the individual freezer power failure alarms from triggering.

All alarms can be acknowledged and escalated to higher-tier users in case no acknowledgment is received from users within a specified time. All alarms are logged, and lab technicians can provide feedback for the cause and resolution of the alarm, which is also recorded.



Example of Reporting

The received real-time and backfilled Nexus data is ultimately stored in the IDX Historian, an industrial-grade time-series optimised database based on the Microsoft SQL Server. The data is openly available for querying, by users with requisite permission, using common office tools such as Microsoft Excel.

The historian uses custom data partitioning to allow it to work even with SQL Express to performantly store and retrieve large amounts of data using even the free Express edition of the SQL Server. The SQL edition was used in this case as it was acceptable for the quantity of data generated and the system use-cases.

A customer-specific web-based user interface was created that allows the customer to view the live status of all the monitored devices and examine historical data and generate application-specific reports based on this data.

The IDX philosophy of a minimalist user-interface design was beneficial not only for usable scaling on different viewing device formats, but also to provide an uncomplicated, responsive user-interface with functionality the customer wanted. IDX was largely left to its own devices to develop a suitable user experience and the functionality we would envision as useful as there was no defined specification or specific guidelines in this regard, beyond some basic requirements.

Conclusion

The final solution allows the user to easily evaluate the status of all the freezers and auxiliary device through simple colour coding of the items representing the devices. All alarm viewing and configuration, data trends and reporting functionality are provided through this single, user access-controlled interface.

In addition, maintenance tasks that were previously paper-based, such as validating the minimum and maximum freezer temperatures per day, are now automated in that the daily temperatures are automatically captured and only require electronic sign-off from a user with the requisite permission to do so.

In this case, the customer currently uses the system principally as an auditing tool, but given the data gathered, the next steps would include further system automation, additional migration to electronic record keeping and data analysis, such as that surrounding power consumption, that would lead to greater operational efficiencies and cost savings.