MISTRAL
... Partners in Real Time

Modular Gateway/RTU Device

Introduction

An industrial gateway is specifically tuned and designed for industrial environments and IoT applications. Like any gateway that operates at the edge of the network, industrial gateways connect devices and resources in the local network environment with remote assets for information/data collection and aggregation. Industrial gateways can link systems employing diverse network protocols, while often providing on-board processing to secure, filter and manage complex data flows. These edge devices can receive data flows from hundreds of individual sensors, and other devices--over network schemes like Ethernet, Wi-Fi and Bluetooth--and funnel them to the network edge where the data can be processed or transmitted.

This case study showcases Mistral's expertise in providing end-to-end product design services for an industrial gateway.

> "This case study showcases Mistral's expertise in end to end design and development of an IoT based Industrial Gateway."

The Customer

The customer is one of the leading companies of the industrial sector that manufactures devices and software with next generation production systems. The company provides turnkey solutions for monitoring the productivity potential of industrial sites and commercial buildings.

The Requirement

The customer approached Mistral to design and develop a Linux based Modular Gateway / RTU device which would capture industrial parameters like temperature and pressure while generating notifications if the parameters cross a defined upper or lower limit. The main features of the product are:

- The gateway to gather or deliver data over MODBUS protocol and IEC62056-2 with a Web based GUI for Configuration and Monitoring
- Compliant to multiple safety and security certifications and regulations (EN 55022, EN 55024, IEC 61000)
- Event-based logging functionality
- Automatic SMS and e-mail notification triggered by defined alarms
- Configuration and Monitoring support through Modbus TCP
- Automatic Meter Reading Web-service Client
- Support for both 2G and 3G GSM, GPRS Interface
- Connection to Open VPN servers
- Connect to VPN servers supporting PPTP and IPSec
- SNMP support, trap broadcast
- Multiple digital / analog input and output interface support
- Support for multiple types of RTDs
- DIN2 enclosure
- Supports Modbus Slave RTU devices
- Multi Language support
- Supporting role based multi-user and multi session.

Solution Provided

Mistral designed and developed the Modular Gateway, managing the entire product development cycle from concept to production. This includes, hardware design, porting of Linux, web-based UI development, middleware development and product qualification.

The product is built around Texas Instruments Sitara processor with following features:

- Eight Analog inputs and Two Analog outputs
- Two RTD inputs
- Eight Digital IOs
- Four Relay controls
- Quad Band and 3G Data connectivity
- Operating supply range: 9-36V
- Operating temperature range of -20^{0}C to 70^{0}C

The initial design and development was done on a reference platform, for early software development. Mistral used this development platform as a reference design, customized it to meet the form factor requirements of the prototype and developed the solution. The Web based/GUI was developed for configuration and monitoring the Gateway. Based on the parameters defined, the product provides alarms and notifications to the user.

Mistral designed the product in two stages - Functional completion that includes design, development and second the Certifications and production worthiness activities.

The Challenges

Device Form factor:

One of the initial challenges faced during the design was to make the gateway unit fit into a DIN2 enclosure of 90mmx140mm size while providing a clear isolation for all the IOs from the processor. To address this, Mistral opted for a two board approach, wherein the processor and related circuitry are on the Main board and the isolated IO sections on the IO board.

Data Accuracy:

Another major challenge was to achieve high accuracy for both analog IOs and RTD inputs. The gateway supports analog IOs with accuracy of 0.1% of FSR at room temperature and 0.3% of FSR over the operating temperature range of -20^{0}C to +60^{0}C.

RTD input supports different types like Pt100, Pt200, Pt500, Pt1000, Ni100, Ni120, General PTCs & NTCs in both 2-wire and 3-wire modes. The gateway supports all types of RTDs mentioned above with accuracy of 0.2% of FSR at room temperature and 0.3% of FSR over the operating temperature range.

To achieve this, high accuracy components were used in the circuitry. For RTD, ratiometric cancellation method was used, in which a constant current is flown through the RTD input & a constant reference resistor. Also, the analog traces were routed via a solid ground plane beneath them. To avoid coupling, spacing of at least 2W is maintained between the traces.

Analog input output calibration:

Even though high accuracy components are used, there were some gain and offset errors associated with the ADC & related circuitry. To correct this error, calibration process was designed and developed for use in the factory. An input from a high accuracy calibrator was connected to the gateway. Based on the actual input value & measured input value over the input range, a correction formula y=mx+c was calculated ('m' corresponds to gain error and 'c' corresponds to offset error). For Analog outputs, as the DAC itself compensated for the errors using feedback of the output, no calibration was required.

RTD calibration:

Since the gateway had to support different types of RTDs, it was not practical to calibrate the RTD based on type. Thus, RTD input circuitry was calibrated with respect to input resistance. A similar correction formula y=mx+c was derived using different samples, so as to correct gain and offset errors of the whole circuitry. With this calibration Mistral's team achieved accuracy of 0.1% FSR at room temperature and 0.2% FSR over the operating temperature range.

Device certifications:

The gateway unit was made compliant to all the below standards

- Radiated Emission and Conducted Emission as per EN55022 Class A
- Radiated Susceptibility as per IEC 61000-4-3 Level 2
- Conducted Susceptibility as per IEC 61000-4-6 Level 2
- ESD Immunity as per IEC 61000-4-2 Level 2
- EFT Immunity as per IEC 61000-4-4 Level 2
- Surge Immunity as per IEC 61000-4-5 Level 2
- Power Frequency Magnetic field Immunity as per IEC 61000-4-8 Level 1Power DIP as per IEC 61000-4-11

General EMI/EMC guidelines along with additional protection diodes were used during design and layout to make sure that these standards meet the desired results.

Interfacing Web and I/O drivers:

The Lighttpd was used as an Embedded Web Server. The Web Server supports PHP, Fast-CGI and Java scripting. Web Pages were developed based on PHP and Java Scripting Language. User-friendly menu based navigation were designed for configuring the Device, Alarms, Modbus Devices and IEC Meters. The user-friendly Dashboard menu displays the complete state of the Device. The IO Channels and low-level Interfaces can be accessed and controlled through PHP-extensions.

Choosing the right Embedded Database:

Sqlite3 was used as an Embedded Database as this has standard SQL interfaces and file-based access. The database was accessed through the C language interface and also through PHP interface from the Web Interface. The multiple sqlite database tables are associated with foreign keys so that update or delete in a table is reflected in other associated tables. Also storing device configuration, Importing and Exporting is supported.

Device Configuration through Modbus TCP Master:

The device can be configured through any Modbus TCP Master device. Most of the Device Configuration parameters are also mapped as Modbus Registers. These Modbus Registers can be configured (Read/Write) by any Modbus TCP Master.

Key Achievements

- Mistral's team worked on the complete product design of the Smart Modular Gateway including developing UI and certifications
- The device was designed to meet all safety and security standards
- Mistral ensured uniform device input/output calibration which required high precision and accuracy
- Mistral achieved very high accuracy RTD inputs which support all RTD types
- Interfacing Web and I/O drivers
- Modbus Device Scan Support for RS-485 ports
- Developed Analog In and RTD calibration application.

Customer Benefits

Modular design:

The design covers multiple product flavors enabling the customer to re-use the design for multiple product lines.

Quicker time-to-market:

Mistral's vast experience in embedded product design and TI's Sitara platforms enabled quick development and reduced time to market, saving time and development cost for the customer.

End-to-end product development:

Mistral's expertise in both hardware and software offered end-to-end services with faster turnaround. This helped the customer to avoid coordination between multiple vendors, saving time and getting the product to market faster.

MISTRAL
... Partners in Real Time

Mistral Solutions Pvt. Ltd.,
No.60, 'Adarsh Regent',
100 Feet Ring Road,
Domlur Extension, Bangalore - 560 071
Tel: +91-80-4562-1100
Fax: +91-80-2535-6444
E-mail: info@mistralsolutions.com

Mistral Solutions Inc.,
43092 Christy Street
Fremont, CA 94538
USA
Tel: +1-408-705-2240
E-mail: usa@mistralsolutions.com

Branch Offices:

INDIA
- Hyderabad
- New Delhi

USA
- Dallas, Texas

www.mistralsolutions.com