Integrating Applied Technology in the Design and Installation of a Solar Powered, Wireless Tank Control System

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- Independent Start-Up Oil Company
  - Limited Engineering and Project Management Capability
- InterAct Technical Solution Provider

Problem

- Prevent Water Tank Overflow on 24/7 basis with 8/5 Operation

Solution

- Design and install a remote, self-contained tank monitoring and water control system
Statement of Work

➢ Objectives
  ➢ Integrate Process Logic Control (PLC) with low voltage, solar powered, tank and pump controls to maintain equilibrium in a water disposal tank.
  ➢ Remote alarm notification to operators via cell phone, prior to well pump shut down.

➢ Deliverables
  ➢ Process and Instrument Diagram (P&ID)
  ➢ Electrical Load Calculations (kW/Day)
  ➢ Control Logic Spreadsheet
  ➢ Component Specification
  ➢ Purchasing Budget
  ➢ Implementation Schedule
  ➢ Operation Manual
Wireless Control Research

- **Existing Wireless Instrument Systems**
  - Wireless 900 MHz radio telemetry is predominant for linking remote pumps and tanks in water distribution systems.

- **Applications**
  - Municipal Water & Wastewater
  - Reservoir Control
  - Oil & Gas Waste Disposal

- **Features & Specs**
  - License-free 900 MHz
  - 20 Mile Range
  - Analog and Digital I/O
  - 10 to 28 VDC Power
Wireless Communication Research

- **Cellular Service Option**
  - Remote location did not offer reliable cell phone service for notifying operators of water tank alarm levels.

- **Satellite Internet Service**
  - Utilize existing satellite service to access Internet and send Short Message Service (SMS) text message to operators cell phone.

- **Ethernet Modem**
  - Wireless 2.4 GHz telemetry provides local area network (LAN) connection between tank control PLC and field office PC.

- **Features & Specs**
  - 802.11b WiFi Compliant
  - Range 6 miles Line of Sight
  - Data Encryption
Tank Control Topology

- **FUEL GAS SHUTDOWN**
  - PLC REMOTE
  - NV SRM 6000 SERIAL MODEM SLAVE
  - NV SRM 6000 SERIAL MODEM MASTER
  - DL FLCL 810E+ ETHERNET MODEM SLAVE
  - DL FLCL 810E+ ETHERNET MODEM MASTER
  - PLC MAIN
  - MAIN WATER TANK
  - ISP
  - ROUTER SWITCH

- **INTERNET SATELLITE**
  - DISH
  - SATELLITE MODEM
  - CAT-6 ETHERNET CABLE
  - 2.4 GHz

- **OFFICE PC INTERNET ACCESS**
  - PLD 810E+ ETHERNET MODEM MASTER
  - CAT-6 ETHERNET CABLE

- **HIGH LEVEL**

- **TEXT MSG** "MAIN TANK HIGH LEVEL"

- **TANK CONTROL TOPOLOGY**

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Process Logic Control Research

- **Rockwell Automation by Allen Bradley**
  - Expensive component cost and education requirements to develop control logic lead to research cost effective PLC solution

- **Lab VIEW by National Instruments**
  - Competitive hardware cost with low power consumption
  - Graphic based, drag and drop style programming
  - Sales Engineering Support
Power Consumption Calculations

**Main Tank System**
- 24 Amp/Hr/Day (24Watts @ 24Vdc = 1 Amp x 24Hr)
  - Controller 6.1 W
  - Relay 3.0 W
  - I/O Module 0.5 W
  - 900 MHz Modem 4.8 W
  - 2.4 GHZ Modem 4.8 W
  - Level Transmitter 3.6 W

**Remote Stations**
- 18 Amp/Hr/Day (9 Watts @ 12Vdc = .75 Amp x 24 Hr)
  - Modem 4.8 W
  - RS 232 Module 1.0 W
  - 422 Relay 1.75 W
  - Solenoid (10% Duty) 1.0 W
Solar Power System Research

- **OKSolar.com**
  - Limited Configuration Information
  - Limited Load Configurations
    - 2.5A 24 Vdc system cost $2,250
    - 50A 24 Vdc system cost $22,500

- **SunWize Technologies**
  - Global Insolation map to calculate peak winter sun hours based on latitude and longitude
  - Fully integrated power supply and battery for 99.9% reliability
  - Multiple web-based configuration options
    - 12V, 120 Amp/hr system $1,997
    - 24V, 252 Amp/hr system $5,767
Tank Control System Installation

- Solar Powered Tank Monitoring System
  - Monitors water level and controls pump speed to maintain setpoint
  - Shuts down fuel gas to wells at high water alarm levels

Wiring the Ultrasonic Level Transmitter for Calibration

LabVIEW PLC with Wireless Modems for Communication
Process Logic Control Requirements

- Variable Set-Points with PLC Control Functions
  - Low Alarm Level
    - Shut down all injection pumps
    - Turn on Yellow and Red Flashing Lights
  - Low & High Warning Levels
    - Send SMS text message to operator cell phone
    - Turn on Yellow Flashing Light
  - Low Pump Limit Level
    - Switch injection pump speed to SLOW
  - High Pump Limit Level
    - Switch injection pump speed to FAST
  - High Alarm Level
    - Shutdown #1 remote fuel gas valve and stop (12) wells
    - Turn on Yellow and Red Flashing Lights
  - High-High Alarm Level
    - Shutdown #2 remote fuel gas valve to stop (12) additional wells
    - Turn on Yellow and Red Flashing Lights
Tank Level Control System

- **PLC Pump Speed Control**
  - User defined setpoint for low and high engine speed
  - PLC controls Murphy throttle positioner
  - Maintains tank level within 2 ft hysteresis

Main Panel with SunWize 24VDC Solar Array

10,000 bbl Water Tank

Graphic User Interface

Water Injection Engines with PLC Speed Control
Remote Fuel Control System

- **Wireless Communication**
  - Main panel sends shutdown signal to remote panels
  - Remote Panels are 12VDC solar powered
  - Control valves use supply gas to operate

![Remote Panel behind Fuel Gas Shutdown Station](image1)

Main Panel with SunWize 24VDC Solar Array

![Fuel Gas Valves](image2)
Tank Control System GUI

- Remote Process Monitoring
  - Graphic User Interface via PC link to PLC provides real-time process monitoring at the facility and remote locations with Internet access.

Compressors

Oil Tanks

Text Msg Control

InterAct
Tank Control System

Wireless Expansion Capability
- Wireless Level Transmitters added to Baker Tanks for high level warning and fuel gas shutdown.
- 900 MHz Radio with 25 mile range
System Integration

Integration Role

• **Mechanical Design**
  - Fuel gas shutdown with field installation

• **Electrical Design**
  - Process control with functional testing

• **Structural Design**
  - Seismic and static loads for solar panel mounts

• **Customer Criteria**
  - Process alarms and response with PLC programmer
System Commissioning

- Solar Arrays
  - Verified for mechanical and electrical integrity

- Wireless communication systems
  - Checked for proper configuration

- Remote PC
  - Configured for Internet access

- Remote fuel gas valves
  - Tested or fail-closed operation
System Troubleshooting

**Electrical-Main Panel**
- **Problem** - No 24 Vdc at the PLC and no 12 Vdc at the modems
- **Cause** – 24 Vdc power polarity was reversed at the incoming leads
- **Solution** – Reverse the leads and replace the fuse on the 24-12 volt power supply

**Wireless Communication**
- **Problem** – 2.4 GHz Modems between PLC and PC were not providing stable link.
  - **Initial Solution** – Assign static IP addresses to both modems and re-configure antennas
  - **Final Solution** - Send modems back to factory for testing and replacement
System Troubleshooting

- **SMS Text Message Failure**
  - **Problem** – PC in the field office unable to send SMS via satellite Internet server due to SSL coding requirement
  - **Solution** – Add programming module to software to encode SMS text with SSL code

- **Fuel Gas Shutdown Operation**
  - **Problem** – Spring Return actuator only opened 50% when gas is applied to actuator due to vendor failure to configure the actuator to meet design specifications
  - **Solution** – Remove several springs inside the actuator to reduce the torque required to open the valve.
Lessons Learned

Communication
• Sub-Contractor project management added additional layer of communication
• Schedule regular team meetings to review project scope and methods to achieve design intent

Scope
• Production requests for additional capability after scope approval.
• Involve all personnel when defining the scope of work and allow for future expansion

Critical Path
• Minor unidentified tasks can dictate the critical path
• Identify all tasks using a timeline (MS Project) with frequent updates to identify potential schedule impacts before the scheduled completion date

Cost Control
• Fixed price quotations evaluation with low cost priority can result in equipment that does not meet customer specifications.
• All RFQ’s need to be written to cover all details with specifications for FAT’s to be performed prior to delivery.
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