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Design and Implementation of an Embedded Interface for I²C to Modbus TCP/RTU Integration

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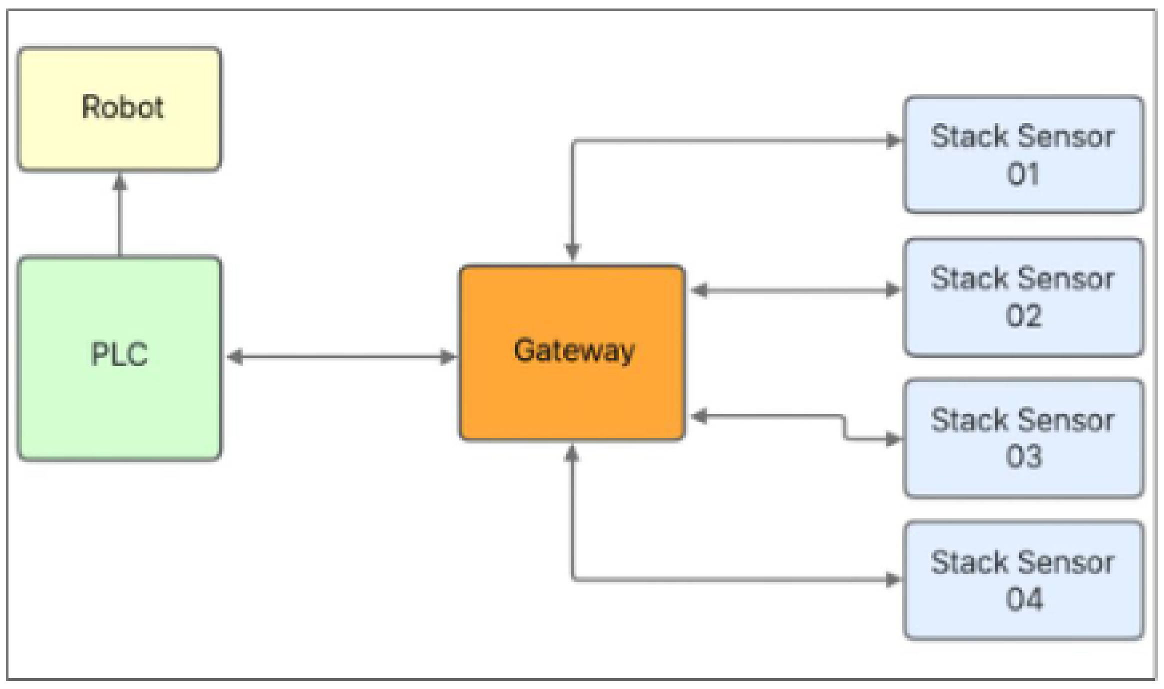
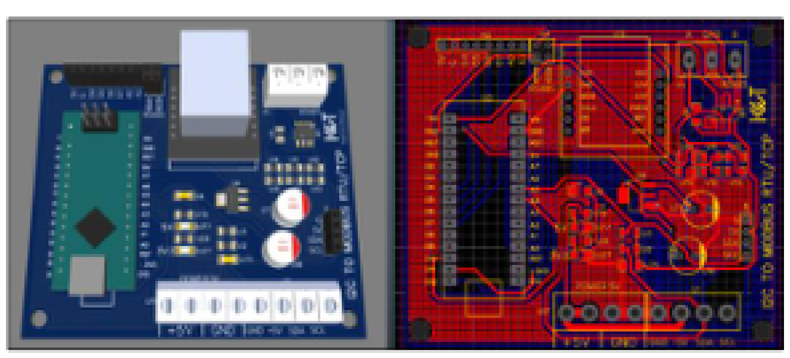
INTRODUCTION & AIM

In industrial automation, integrating heterogeneous sensors and controllers is essential, especially in lines using Surface Mount Technology (SMT) manufacturing methods that require precise measurements. Sensors such as TF-Luna operate on I2C, while some Programmable Logic Controllers (PLCs) such as DELTA AS228T use Modbus TCP, creating compatibility challenges. This work presents an embedded solution that functions as a gateway and unites these protocols, enabling efficient communication in industrial applications.



METHOD

The methodological approach adopted in this work is based on practical and iterative integration between the stages of analysis, development, and validation, considering the real needs of industrial environments based on SMT lines. The process began with a detailed analysis of the functional and communication requirements of the industrial application, identifying the need for integration between LiDAR sensors and the AS228T PLC, whose native communication is not compatible. Based on these requirements, a careful selection of the microcontroller was made, taking into account the ability to support multiple I2C sensors and implement a robust stack of Modbus TCP communication over industrial Ethernet. The choice fell on the STM32 family, recognized for its extensive documentation and stability in embedded applications. After the integration phase, the system underwent bench testing, where the interface was After the integration phase, the system underwent bench testing, where the interface was validated for communication stability, measurement accuracy, and response capability under different scenarios.



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16:52:06.512 -> Scanning I2C 7-bit address range 0x08 to 0x77.
16:52:06.512 -> I2C device found at address 0x20
16:52:06.559 -> Scan complete.  Devices found: 1
16:52:06.605 ->
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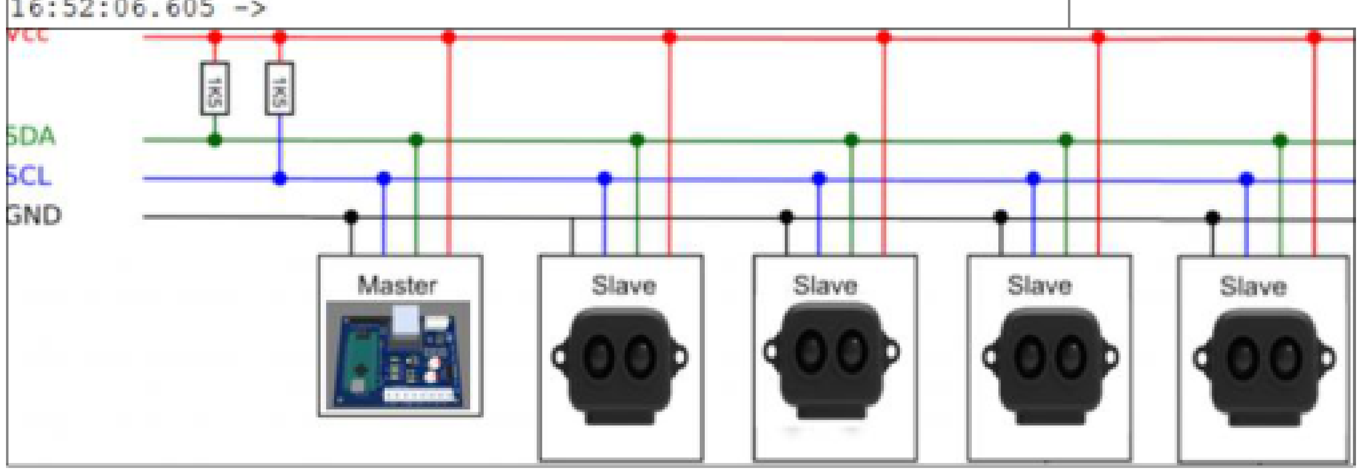
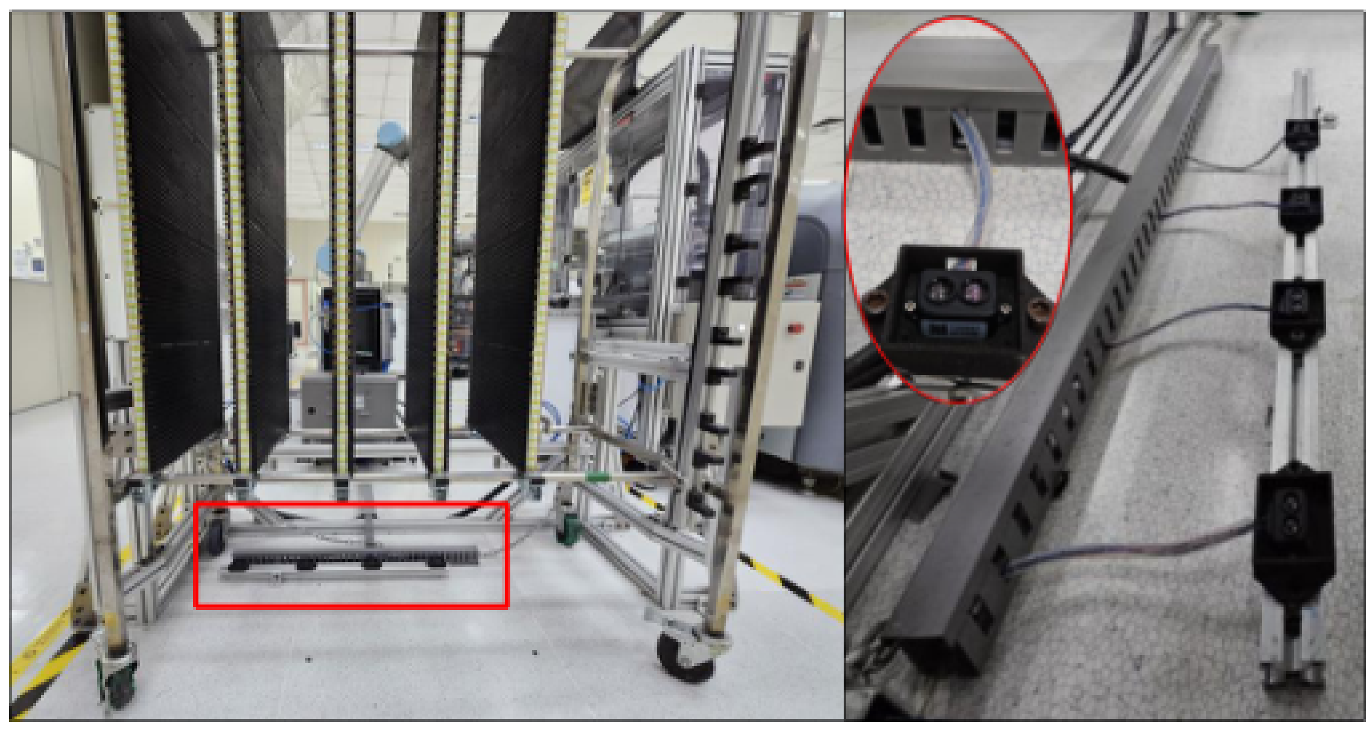


RESULTS & DISCUSSION

Bench tests demonstrated that the proposed interface provided stability and accuracy in reading multiple TF-Luna sensors. The average response time of the system was less than 50 milliseconds, maintaining continuous updating of measurements in the PLC, ensuring proper synchronization of the robot during the plate handling process. The robustness of the interface was proven in simulated electromagnetic noise scenarios, a common feature in industrial environments. In addition, the expandability of the system was verified, as it can support other types of sensors or protocols through firmware adjustments. After bench testing, the project was assembled in a manufacturing environment where it performed extremely well, maintaining the process cycle time at 100%.



CONCLUSION

The interface developed proved to be an effective solution for integrating TF-Luna LiDAR sensors in I2C with the DELTA AS228T PLC via Modbus TCP, ensuring stable communication, accurate measurements, and reliable operation even in industrial environments with high electromagnetic noise. The tests confirmed the robustness, low response time, and expandability of the system, highlighting its potential for applications in SMT lines and other Industry 4.0 demands.

FUTURE WORK / REFERENCES

As an evolution of this work, we intend to:

- Expand interface support for protocols such as OPC UA and MQTT, enabling integration with industrial IoT platforms and modern SCADA systems.
- Incorporate security mechanisms based on TLS and device authentication, complying with cybersecurity standards for industrial networks.
- Conduct tests in a real production environment, validating robustness in practical production line situations.
- Develop tools for remote configuration and monitoring of the interface, using responsive web interfaces.

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