extending **I/O Interfaces** for Phoenix Contact PLC using **ESP-NOW** wireless microcontrollers

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Abstract **-** Due to technological advances, the need for versatile and flexible applications in the field of industrial automation is continuously growing. Digitalization, flexibility, connectivity, high-speed transmission, data analysis and integration of different systems are now requirements in most industries. Industrial communication networks are the main tool in accomplishing those requirements. The proposed work is focused in the development of a solution for collecting remote field signals and transmit them by wireless technology for a Phoenix Contact PLC with fieldbus communication capabilities. Based on microcontrollers (Adafruit's ESP32), the final architecture has a manager module, or Master, and two input and output digital and analogue (I/O) modules, or Slaves, which communicates through the native ESP-NOW wireless protocol of the microcontrollers.

Keywords **-** Industrial Automation; I/O remote integration; SPI; ESP-NOW; Modbus TCP/IP; Phoenix Contact PLC.

I. Introduction

Most industries are going through a phase of great digital transformation. To respond to a higher demand for goods and services, it is essential to continuously update and optimize automated systems [1]-[4] In this sense, wireless communication networks can play a key role in the process of integration, compatibility, and cost reduction. Currently, the Wi-Fi technology, specified by various IEEE 802.11 protocol standards, is designed to work seamlessly with its wired equivalent, the Ethernet. This offers the opportunity to explore a fully compatible Ethernet interface solution filling the requirements of high-speed data transmission, reliability, robustness and easy integration at reduced cost. The proposed solution presents a low cost solution to interconnect remote binary and analog inputs and outputs (I/O) interfaces with an industrial Phoenix Contact PLC (Programmable Logical Controller) in order to extend the local interfaces. The proposed solution is a mix of wired fieldbus communication and Wi-Fi technology, presenting good response time and robustness, which is acceptable for most industrial applications.

II. Proposed solution

A. General Overview

The main goal was the development of a digital unit to exchange data with the available protocols in the PLCs to interconnect remotely with a group of binary and analog inputs and outputs (I/O) interfaces. Thus, allowing to extend the available local interfaces and obtain data or force remote devices operating in other workbenches. The general concept of the proposed solution can be seen in Figure 1. The solution consists of a main module (or Master module), and remote modules (or Slave modules). The main module is composed by an Adafruit ESP-32 microcontroller board, connected to an Ethernet network card (Adafruit Ethernet Feature Wing) supported by a network chip WiZnet W5500. They are connected through a serial communication interface, namely the SPI (Serial Peripheral Interface) standard. This Ethernet network interface allows the physical connection between an industrial PLC and the main module using the Modbus TCP/IP protocol available. The microcontroller is built around ESP32-S3 series of SoCs, Xtensa dual-core 32-bit LX7 microprocessor with embedded 2.4 GHz Wi-Fi (802.11 b/g/n).

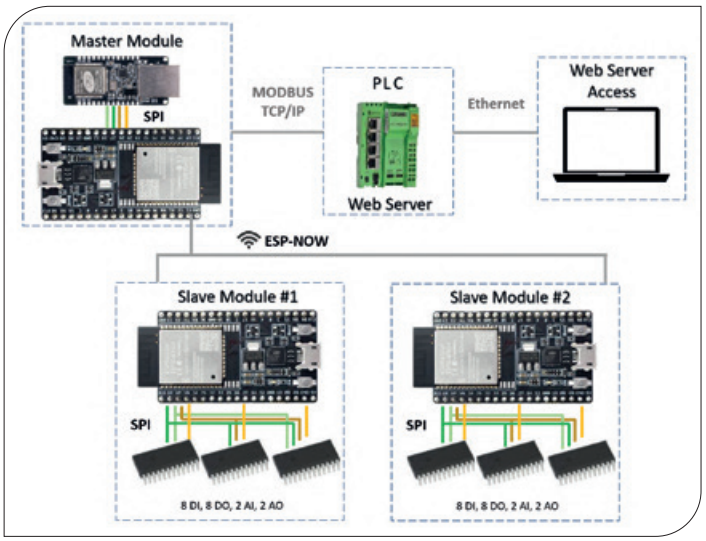

Figure 1 *General concept of the proposed wireless I/O Interfaces solution.*

The slave modules are also ESP-32 based with ESP-NOW technology to exchange wireless data with the master module. Each slave module have locally dedicated hardware to read and write binary and analog I/O data whenever needed. This is obtaining through the SPI (Serial Peripheral Interface) protocol connected to each DAC (Digital to Analog Converter) and ADC (Analog to Digital Converter) integrated circuits available in each server module (see slave modules in Figure1). Each slave module have two analog inputs (Microchip MCP3204), two analog outputs (Microchip MCP4922) eight digital inputs and eight digital outputs (Microchip MCP23S17). All the connections between the microcontroller and other hardware is galvanically isolated using the MAX14430 integrated circuit.