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Design and Implementation of User Configurable Industrial Human Machine Interface (Hmi)

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***Abstract*: -- In process automation industry, operator interface is usually a Human Machine Interface Unit (HMI) which plays a significant role in creating a friendly visual environment between the user and the technology. It is considered to be the window to the automation control system. Controlling through finger touch has replaced the use of hammers and manual switches enormously. With the increasing application of HMIs in industry, a good number of software tools are being introduced and the competitiveness in designing HMI displays is increasing tremendously. This project focuses on various important aspects in designing HMI displays to meet the quality criteria such as ease and seamlessness in user understanding, efficiency of learning the HMI design software tools and satisfaction of the operators to control large systems. These aspects consist of issues with screen layout, color representation, graphics and pictures, text and data values, alarms, navigation, control and so on. The scope of this project is to gain knowledge about how to implement as much application in one limited display monitor, by multiple numbers of pages in a graphical hierarchy. This is needed to provide an operator with clear visual understandings of process operations with both moderate and complex applications. This project also consists of appropriate guidelines for designing an HMI unit in a most efficient way. As an example, we have designed an HMI unit intended to control a water bottle filling plant through Programmable Logic Controllers (PLC) systems.**

Index Terms: **Distributed Control System (DCS), Human Machine Interface Unit (HMI), Programmable Logic Controllers (PLC).**

I. INTRODUCTION

In recent years, industry has grown exponentially and Growth in industrialization has increased the efficiency. In process automation industry, operator interface is usually a Human Machine Interface (HMI) Unit. HMI plays a significant role in creating a friendly, visual environment between the user and the technology. It is considered to be the window of the automation control system. Controlling through finger touch has replaced the use of manual switches enormously. The user interface, in the industrial design field of human machine interaction, is the space where interactions between humans and machines occur. The user interface in a manufacturing or process control system provides a graphic-based visualization of an industrial control and monitoring system which is previously called as MMI (Man Machine Interface). HMI typically resides in an office-based Windows computer that communicates with a specialized computer in the plant such as a Programmable Automation Controller (PAC), Programmable Logic Controller (PLC) or Distributed Control System (DCS). The HMI device, the operators can manage their industrial and process control machinery using a computer-based user interface. The HMI is the computer or handheld device. Basically, there are two types of HMI: supervisory and machine level. The first type, i.e. supervisory level [1], is designed for room control environments and used for system control and data acquisition (SCADA), referring to process control application that collects data from sensors on the shop floor and channeled the information to a central computer for further processing. The latter types, i.e. machine level HMI use embedded, machine-level devices within the production facility itself. However, most Human Machine Interface (HMI) device is designed to operate either supervisory or machine level. The Human Machine Interface (HMI) system is the flow of information between a user and a device. Any changes to the HMI have the potential to enhance or degrade that flow, thereby affecting the efficiency, safety, or use of the system. Based on the input requirements of the system and the type of information to be presented, there are many types of HMI to consider, such as natural language interfaces, graphical HMI with or without virtual reality facilities, tactile instruments, and force sensing/reflecting devices. An ideal HMI will efficiently combine the strengths of a human, such as fast and adaptive decision making, with those of a computer, such as rapid processing and retrieval of data. A readily used interface is the graphical HMI, typically displayed on a monitor and often used in combination with a keyboard, mouse, or trackball. Lighted buttons, dials, and GUIs on touch screens are also visual representations of information with the capacity of the physical input of data. Graphical HMI can also use virtual reality scenes or video feeds to display a physical situation or the status of a device[2]. An analysis of products specifications and features are vital in selecting Human Machine Interface (HMI) device. Beside these, other important considerations are: - system architectures, standards and platforms, ease of implementation, administration, use and performance,

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scalability and integration, total costs and pricing. Some (HMI) device provides data logging, alarms, security, forecasting, Operations Planning and Control (OPC), and ActiveX technologies. Others support data migration from legacy systems. Communication on multiple networks can support up to four channels. Supported networks include Control Net and Device Net. Control Net is a real-time, control-layer network that provides high-speed transport of both time-critical I/O data and messaging data. Device Net is designed to connect industrial devices such as limit switches, photoelectric cells, valve manifolds, motor starters, drives, and operator displays to Programmable Logic Controllers (PLC) and Personal Computers (PC).

II. LITERATURE REVIEW

The HMI device evolved since 1950. The modification and development also been observed to make the monitoring and control equipment efficient and effective. Qianqian Jia et al designed the human machine interface (HMI) has been developed to ensure the safety and availability of the two-modular high-temperature gas-cooled reactor nuclear power plant in China. As the first design for the plant with two modules coupled to one steam turbine, the staffing arrangement and HMIs were different from current nuclear power plants (NPPs). One control room was used to monitor and control the two reactor modules, the turbine generator, and the balance-of-plant (BOP). Considering the digital control room style, the elements of the HMIs in the control room where the large display panels and control consoles [1],[3].
Francesca De Crescenzio et al Designed Virtual Reality based HMIs (Human Machine Interfaces) of Complex Systems. The aeronautical transport system was rapidly growing and more demanding. It became a total system of complex systems in which the human was recognized as the decisional point that was asked to act quickly and safely. In this context, innovative technologies provided the challenge to design revolutionary Human Machine Interfaces for the people involved[4].
He Yang et al proposed the system design of ARM-based human-machine interface of plastic injection blow molding machine monitor system which takes ARM7embedded processor as the core and takes CAN bus as a communication system. By analyzing the Human-machine interface system requirements, hardware used LCD screen, touch screen and keyboard as man-machine interface display and input device, used the LPC2478 with ARM7 microprocessor, large capacity memory and CAN communications interface circuits as man-machine interface control device[5].
Chandrashekhar Ghule et al proposed the system to design HMI for multipurpose Electrocardiography using higher level language. Unlike any other software, where in the hardware was changed, there was a need to bring subsequent change in the software, this HMI can be used as a general purpose software for ECG analysis with any kind of hardware. The same analyzing system can be used to perform allied other functions. It is used to filter the signal coming from the hardware so as to eradicate any kind of noise present. It not only displayed the 12 lead ECG signals on the LCD screen, but simultaneously stored it in the memory of the system[6].
Z. Wang et al Created design research of product appearance based on human–machine interaction and interface this system adopted converse design thinking and presented an improved design thinking methodology based on Constraint: Function Behavior Structure (FBS) for product appearance design and gave a general summarization of the features, methods and technology based on human–machine interaction and interface (HMI&I). At the same time it also combined with the behavior design of product related IT fields and constructed a new outline to improve the design of product appearance supported by the technology of computer aided design (CAD)[7].

III. HMI MODULE

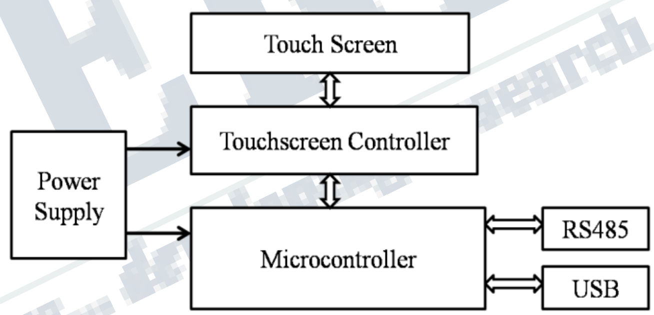

Figure 1.1 Block diagram of HMI Module

A. Touchscreen:

A touch screen sensor is a clear glass panel with a touch responsive surface. The touch sensor/panel is placed over a display screen so that the responsive area of the panel covers the viewable area of the graphical screen. The sensor generally has an electrical current or signal going through it and touching the screen causes a voltage or signal change. This voltage change is used to determine the location of the touch to the screen. The touch screen is used as an I/O device in the system. The touch screen display and Microcontroller interface with touch screen controller to control various applications and monitor the system. Here, Graphical User Interface (GUI) with TFT (Thin Film Transistor) technology LCD display is used for ease of system monitoring, 4-wire resistive touch screen is used to input the value and access the system parameters. The source of the digital signals is a microcontroller with a basic serial interface. Each communication between the microcontroller and the touch screen controller, such as Serial Peripheral Interface (SPI) interface. The visual GUI offers an intuitive interface and component based embedded application development to speed up your work and controlling process. The TFT LCD touch screen display will show the desired parameters set by the operator. The operator will be able to keep an eye on parameters which are set as per the requirement like Temperature, motor speed, motor status etc.

B. Touchscreen Controller:

The touchscreen controller can convert analog to digital, an analog input, which came from touchscreen panel and controller convert to digital output send to microcontroller with the help of Serial Peripheral Interface (SPI) interface. It is a 4-wire resistive touchscreen controller. The ADS7846 is a classic Successive Approximation Register (SAR) Analog-to-Digital (A/D) converter.

C. Microcontroller:

It consists of ARM CORTEX M4 CORE Microcontroller where everything will be stored in controlling task as per program feed and display on the screen.

D. Power Supply:

There is a provision for both isolated and non isolated power supply as per customer requirement. The power supply provides required voltages to Touchscreen controller and Microcontroller.

E. Communication:

The HMI is designed to have up to two communication ports. Each of the ports can be defined as Modbus slave or can connect to various third party devices such as PLC's, Drives, PID Controllers, etc. The Inside the same slots, the user can be used communication port for programming the PLC. The USB serial communication port will be provided as the input unit to the system programming. The RS485 port provides communication interface to third party devices such as PLCs and drives. Communication protocols running over RS485 fetches data from a PLC and display it on the HMI screen. Touch screen HMI is used to update data in the PLC.

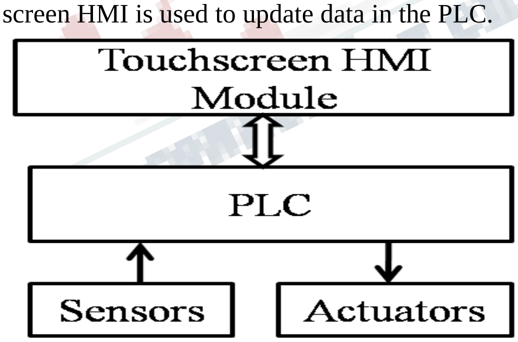

Figure 1.2 Application of HMI Module

Figure 1.2 shows the application of HMI system. The RS485 port provides communication interface to third party devices such as PLCs and drives. Communication protocols running over RS485 fetches data from a PLC and display it on the HMI screen. The HMI touch screen is used to update data in the PLC.

Touch screen HMI, also referred to as User Interface, Operator Panel or Terminal, provides a means of controlling, monitoring and managing device processes. An example is an operator panel which allows an industrial machine operator to interact with a machine in a graphical, visual way. With controls and readouts graphically displayed on the screen, the operator can use either external buttons or the touch screen to control the machinery. Ranging from simple segmented displays to high-resolution LCD panels, HMIs can be located on the machine, portable handheld devices and also in centralized control rooms. They are used in machine and process control to connect the sensors, actuators and machines on the factory floor to I/O control and PLC application systems. An industrial HMI system's usability is determined by its processing power, its ability to render complex and reality like screens, its fast response time to user input and its flexibility to handle various levels of operator interactions.

The objective of this project is to make HMI user configurable. Software (Flexisoft) running on PC provides a tool for user to create HMI screens, define tasks for objects like buttons, configure communication protocols. The project created using the HMI software gets downloaded into HMI system. Firmware running in HMI makes use of user application to respond to operator command and display information.

IV. CALIBRATION OF TOUCH SCREEN

So as to linearize ADC count to 0-256 range, we need to implement linearization algorithm according to the equation,

$Y = mX + C$

The gain and offset calculated by the straight line equation. The calibration program is applied to the signal generated by the associated touchscreen panel. The gain and offset which are determined in the program are calculated as follows. It is assumed that, the signal generated by the touch screen is linear between the low and high limits. The relationship between the values, of the actual LCD outputs generated by low and high reference signals, injected into the touch screen and the expected inputs are shown graphically in Figure 5.1. The straight line represents the transfer function for any value of the input signal.

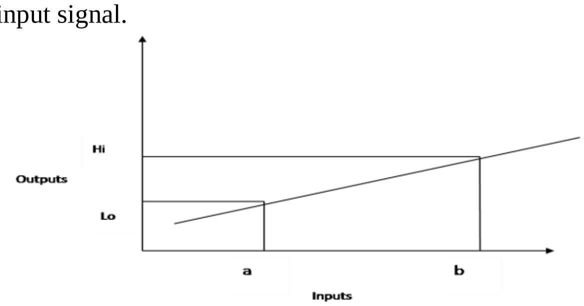

Figure 5.1 Linearizaton curve

Y= mX+C….(5.1)

Substituting the variables a and b, for the low and high reference signals of touchscreen and the measured LCD resolution full scale low and high values, Lo and Hi, the following equations are obtained:

Lo=m*a+C……. (5.2)

Hi=m*b+C…… (5.3)

C=Lo-m*a…..... (5.4)

C=Hi-m*b…..... (5.5)

Solving equations 4 and 5 simultaneous for g yields the gain, m:

m= ……… (5.6)

Substitution of this value into either of the equations (5.5) will provide the offset value c.

C=Hi-m*b

=Hi - *b…… (5.7)

V. CONCLUSION

The purpose of our project is to provide a greater operational mobility, as touch screen allows an operator to move freely around the workspace and drive automation plant with simple graphical user interface. With the help of implemented system using GUI, one can interface all the peripheral devices, sensor and power circuitry from the control room, and monitor the different parameters also. Any system that needs to control or monitor objects from one place, can thus be designed with ease and also it will make the processes involved to be safe, reliable, inexpensive, accurate, least time consuming and decreased labor, which is need of many industrial applications. The GUI based user interface is designed for both experienced and inexperienced computer users. There is no special skill required for operating the system. When one touches the desired icon to perform the specific operation, the accuracy with simplicity is achieved by a simple touch, thus reducing the hiccups in processes. It results in reprocessing a job and subsequently saving cost and time. This application is made using the I/O expansion card. Using PLC the cost for the application will be higher, but, as the I/O expansion card is much cheaper compared to PLC the overall cost of application is decreased significantly. This is very important in small work scale industries considering cheaper cost.

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