Low End Human Machine Interface (HMI) Display using ARM Cortex M4 Based Controller

Nishu Patel
PG Student
Department of VLSI and Embedded System
U V Patel college of Engineering,
Kherva ,Mehsana, India

Ekata Mehul
Head
eiTRA, Ahmedabad, India

Upendra Patel
CEO
Glide Technology, Ahmedabad, India

Abstract

As industrial environments become more improved and connected; automation technology is developing at a rapid pace. To deliver the communication features and intelligence required at the plant floor and beyond, developers need solutions that can provide advanced, yet cost effective Human Machine Interface (HMI) features. Many industrial automation companies are providing innovative solutions to improve monitoring and controlling processes across a diverse range of industries. This paper includes detailed survey about different Human Machine Interface control panels, applications where these displays can be used, user level advantages of these panels in industry and design to develop low cost entry level HMI panel.

Keywords: HMI (Human Machine Interface); PLC(Programmable Logic Controller); ARM Cortex M4 Based Controller; LCD Touch Panel

I. INTRODUCTION

In the industrial automation domain of human-machine interaction, the user interface is where interaction between humans and machines occurs. The goal of interaction between a human and a machine at the user interface is effective operation and control of the machine, and feedback/status of operations from the machine which aids the operator in making operational decisions. In other words, The HMI includes how people communicate instructions to computing systems, what computing systems provide in response, and how hardware, software, systems, and devices can be designed to do more to expand human control and reach.

For a manufacturing line to be integrated with an HMI, it must first be working with a Programmable Logic Controller (PLC). It is the PLC that takes the information from the sensors, and transforms it to Boolean algebra, so the HMI can decipher and make decisions. The HMI system usually presents the information to the operating personnel graphically, in the form of a mimic diagram. This means that the operator can see a schematic representation of the plant /system being controlled.

HMI products are developed to make machinery easier to operate, while producing optimal outputs. Predecessors of HMI include the Batch Interface, Command-Line User Interface, and the Graphical User Interface (GUI) which is used nowadays in HMI display panels to make user friendly system. HMI control panels are basically of three types: (1) the pushbutton replacer, (2) the data handler, and (3) the overseer. Before the HMI panels came into existence, a control might consist of hundreds of pushbuttons and LEDs performing different operations and monitoring system.

The pushbutton replacer HMI has streamlined manufacturing processes, centralizing all the functions of each button into one location. The data handler is perfect for applications requiring constant feedback from the system, or printouts of the production reports. With the data handler, you must ensure the HMI screen is big enough for such things as graphs, visual representations and production summaries. The data handler includes such functions as recipes, data trending, data logging and alarm handling/logging.[5] Often these Data Handlers come equipped with large capacity memories. Finally, anytime an application involves SCADA (Supervisory Control And Data Acquisition) or MES (Manufacturing Execution Systems), an overseer HMI is extremely beneficial. The overseer HMI will most likely need to run Windows, and have several Ethernet ports. These are centralized systems that monitor and control entire sites or complexes of large systems spread out over large areas. An HMI is usually linked to the SCADA system's databases and software programs, to provide trending, diagnostic data, and management information.

A. Advantages of HMI Panels in Industry:

1) HMI panel with high quality graphics for realistic representations of machinery and processes will give ease to control and monitor plant.

2) HMI improves communications among various types of equipment.
3) A single HMI can replace hundreds of Push buttons, selectors, LED lights and so on. It can reduce cost of hardware and complexity of cables all over the plant.
4) Alarms and warning indicators are also a part of HMI panel to locate any malfunction of equipment and react faster.

B. Applications:

HMI operator panel can be used in various industries including manufacturing plants, vending machines, food and beverage, pharmaceuticals, automation industry and utilities. HMI panel with PLC can be act as a backbone in production line to improve manufacturing operations and to control all aspects of the manufacturing line, such as speed, efficiency, error detection and error correction.

C. Various Types of HMI Panels

(1) Basic HMI operator panel come with RISC processors to satisfy the stringent standards required in the automation market, with support for over 450 PLC industrial communication protocols can fulfill the needs of different applications. (2) Industrial panels are also used for high end versions of HMI which run on operating systems such as Windows XP, Vista, 7, 8, XPe, CE and Linux.

II. COMPARATIVE STUDY OF HMI PANELS

Various control panels for HMI are manufactured by companies like Siemens, Schneider electric, ABB, Anaheim Automation, Advantech, Beckhoff, Red Lion, Kontron, Nexcom, etc.

Main unit of HMI panel is controlling unit that can be a processor or a microcontroller. Depends on features and communication interfaces provided on HMI board, controlling unit varies. Most suitable processors for entry level HMI panel are ARM9 and Cortex M0. ARM Cortex-M based microcontrollers are perfect for the entry-level tier of the HMI market supporting up to WVGA displays, simple user interfaces and key industrial connectivity options. Suitable microcontrollers based on ARM cortex M0 are Freescale Kinetis L-Series, NXP LPC120x series, ST STM32L0 Series, etc. ARM cortex M4 based microcontrollers are Freescale Kinetis K-series, NXP LPC4000 series, TI Tiva C-series, ST STM32F4 series, etc are suitable for mid level of HMI panels. ARM Cortex-A series of processors are the best fit for the base, mid- and high-end markets with speeds ranging from 300 MHz to 1 GHz. The processor portfolio includes unique combinations of industrial interfaces, communication protocol capabilities, and accelerators to expand connectivity options.

HMI control panels support a variety of LCD screens with sizes from 3.5" to 15" and resistive touch. To connect HMI panel with different modules like PLC, USB drive, computer or another HMI panel, certain communication interfaces are provided such as USB, Ethernet, serial RS-232 or RS-485, etc.

Control panel distributor companies provide different models as shown in table.

Table – 1
Comparative Study of Four HMI Panels [1][2][3][4]

Company name	*HMI model description*	
	Product Name	*Features*
Siemens	*Simatic HMI*	*Wide-screen TFT, 65k colors, 32 bit RISC processor, 2-port Ethernet switch, upto 10MB user memory*
ABB	*CP600*	*ARM cortex A8 processor, two 10/100 Mbit Ethernet, Two USB ports, Brilliant colored display, reusable 3D graphic elements*
Schneider Electric	*Magelis GTO*	*333 MHz RISC CPU, Three Ethernet (10BASE-T /100BASE-TX), Recipe management, barcode readers*
Advantech	*WebOP-2070T*	*Supports ARM9-based CPUs with 200MHz and 128MB flash memory, RTC, battery backup RAM, and Ethernet-based operator panels, Supports runtime data downloads through Serial, Ethernet, USB*

III. BLOCK DIAGRAM OF HMI PANEL

HMI board consists of controller based on ARM Cortex M4 core and architecture offers a 120 MHz Cortex-M with FPU, a variety of integrated memories and multiple programmable GPIO. The HMI board's design highlights the microcontroller's USB 2.0 On-The-Go/Host/Device (OTG/Host/Device) interface, the 10BASE-T/100BASETX Ethernet controller with internal PHY, SSI bus to communicate with an external flash device, 12-bit Analog-to-Digital Converter (ADC), LCD controller, and the I2C module. Board uses different modules of microcontroller such as PWM, LCD controller, internal PHY, ADC, UART, GPIO, USB PHY, Internal RTC, etc for different functionality of HMI.

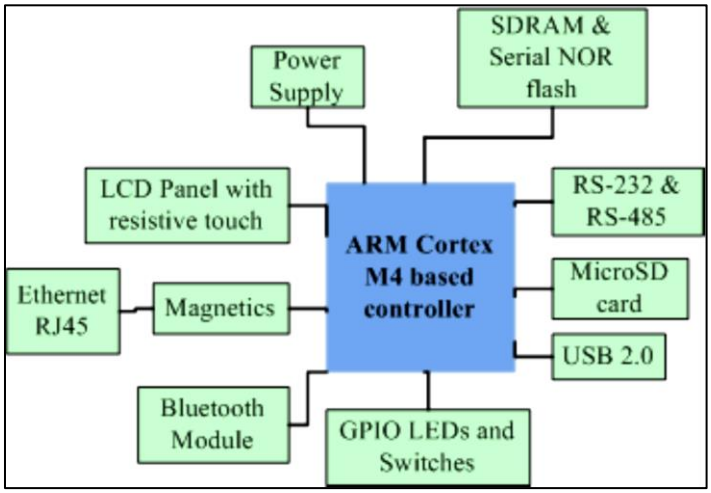

Fig. 1: Block Diagram of HMI Panel

A. Controller Specification on Board

ARM Cortex-M4 microcontrollers provide top performance and advanced integration of rich communication features to enable a new class of highly connected designs with the ability to allow critical, real-time control between performance and power. The microcontrollers feature integrated communication peripherals along with other high-performance analog and digital functions to offer a strong foundation for many different target uses, spanning from human machine interface to networked system management controllers. TI Tiva C-series cortex M4 core controller has many inbuilt modules which can be used to provide rich HMI application.

Table - 2
Features of TIVA C Series Controller

Feature	*Description*
Core	*ARM Cortex- M4F processor core*
Performance	*120 MHz operation; 150 MIPS performance*
Flash	*1024 KB Flash memory*
System SRAM	*256 KB single-cycle System SRAM*
EEPROM	*6KB of EEPROM*
UART	*Eight UARTs*
Inter-Integrated Circuit (I2C)	*Ten I2C modules with four transmission speeds*
Ethernet MAC	*10/100 Ethernet MAC*
Ethernet PHY	*PHY with IEEE 1588 PTP hardware support*
GPIO	*15 physical GPIO blocks*
Analog-to-Digital Converter (ADC)	*Two 12-bit ADC modules, each with a maximum sample rate of two million samples/second*
Digital Comparator	*16 digital comparators*
Universal Serial Bus (USB)	*USB 2.0 OTG/Host/Device*
LCD Controller	*Configurable LCD controller with passive and active matrix LCD panel support*
Hibernation Module (HIB)	*Low-power battery-backed Hibernation module*

B. LCD With Touch Panel

HMI board has 16-bit parallel (Extended up to 24-bit), 7" TFT LCD would be interfaced with Capacitive/Resistive Touch Panel. Features of LCD display are 7" Display size, TFT (262k colors) Transmissive type, 800 x 480 Resolution, White LED backlight, 24-bit parallel Interface, etc. Controller's inbuilt LCD controller and resistive touch screen controller up to 8 wires eliminates any additional display controller IC and reduce design complexity. Controller has inbuilt LCD controller (Raster mode controller) handles the synchronous LCD interface. In-built ADC module of controller can be configured to operate a as 4-wire, 5-wire and 8-wire Resistive Touch screen interface.

C. Ethernet Interface

In HMI, Ethernet can be used as a Real-time industrial communication protocol. Ethernet connectivity allows you to connect multiple HMIs, Read/write from one graphic HMI to any of the PLCs in your local network, monitor & control PLCs from any HMI present on the field. ARM cortex M4 based controller has these features for Ethernet controller: Conforms to the IEEE 802.3 specification, 10BASE-T/100BASE-TX IEEE-802.3 compliant, Supports 10/100 Mbps data transmission rates, Supports full-duplex and half-duplex (CSMA/CD) operation, Supports flow control and back pressure, etc. The integrated PHY of controller supports 10Base-T and 100Base-TX signaling. It integrates all the physical-layer functions needed to transmit and receive data on standard twisted-pair cables. The PHY directly interfaces to the integrated Media Access Controller (MAC).

D. Universal Asynchronous Receiver/Transmitter (UART)

In any kind of Industry most of the communication happens on serial Interface. RS232 used to send data to PLC or any other machine which is in nearer field (100 to 200 meter). For longer distance (1km) RS485 is used. HMI has one RS232 port and one Isolated RS485 port. Isolated RS485 is useful for low, medium and high data rate requirements as well as to accommodate the need of half & full duplex operation. The controller includes eight Universal Asynchronous Receiver/Transmitter (UART). Programmable baud-rate generator allowing speeds up to 7.5 Mbps for regular speed (divide by 16) and 15 Mbps for high speed (divide by 8), Separate 16x8 transmit (TX) and receive (RX) FIFOs to reduce CPU interrupt service loading, programmable FIFO length, including 1-byte deep operation providing conventional, double-buffered interface, Standard asynchronous communication bits for start, stop, and parity, Fully programmable serial interface characteristics like 5, 6, 7, or 8 data bits, Even, odd, stick, or no-parity bit generation/detection, 1 or 2 stop bit generation, Modem function availability, etc. HMI system uses three UARTs RS232, RS485 and Bluetooth interface.

E. USB (Universal Serial Bus)

USB Host can be used for mass storage devices such as Pen drive, Hard drive etc. USB OTG can be used as a Host or Device. If HMI system is connected to any Personal Computer, system will act as a Device. HMI board has two high speed USB port which supports 480Mbps speed. One is USB 2.0 Host with Standard Type A and Second is USB 2.0 OTG with mini AB connector. The USB controller module of microcontroller operates as a full-speed or low-speed function controller during point-to-point communications with USB Host, Device, or OTG functions. Controller supports four transfer types: Control, Interrupt, Bulk, and Isochronous.

IV. CONCLUSION

HMI control panel gives an advantage of the technologies of each sensor, and optimizes human performance during the interface event. Key human factors include safety, ease of use, and clarity for understanding. Machine factors involve device communications, data collection, and data presentation within the context of time. ARM Cortex M4 based controller has many communication interface modules inside, so we can use it to communicate with external modules like PLC, Ethernet switch, USB keyboard, barcode scanner etc or with computer.

REFERENCES

[1] SIMATIC HMI panels of the latest generation by www.siemens.com
[2] "Magelis GTO HMI panel features", Human/Machine interfaces Optimum Advanced Panels catalogue by Schneider Electric
[3] "CP600 series control panels", Industrial Automation & Motion PLCs, HMIs, Software, Drives, Servo Drives, Motion Controllers catalogue by ABB
[4] "WebOP-2080T", 8" SVGA Operator Panel with WebOP Designer Software by Advantech, Mar-2014
[5] "Basic types of HMI" Anaheim Automation, 2015