Human Machine Interface (HMI) Guide

TEXAS INSTRUMENTS

Industrial Automation Solutions

Human Machine Interface (HMI)
Overview

TI's HMI system solutions speed the design cycle with the right devices, software, tools and support.

Human Machine Interface (HMI), also referred to as User Interface, Operator Panel or Terminal, provides a means of controlling, monitoring, managing and/or visualizing 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 read-outs 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, in battery-operated, 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.

HMIs require dynamically changing graphics which, in turn, require a high-performance solution that can achieve the 60 frame-per-second refresh rate that is required at the right resolution. They also have to support multiple connectivity and communications protocols to communicate between the operator and various machines and control systems.

TI's comprehensive range of HMI solutions offer the right mix of performance and peripherals to meet the needs of each application category.

HMI Form Factor	Requirements
High end	• Up to WUXGA display • 2D/3D graphics • User interface application • Video playback • HTML5
Mid end	• Up to XGA Display • 2D Graphics • User interface application
Base	• Up to XGA display • Light-weight user interface
Entry	• Up to QVGA display • Simple user interface

With a wide range of HMI solutions, TI has product to fit every need.

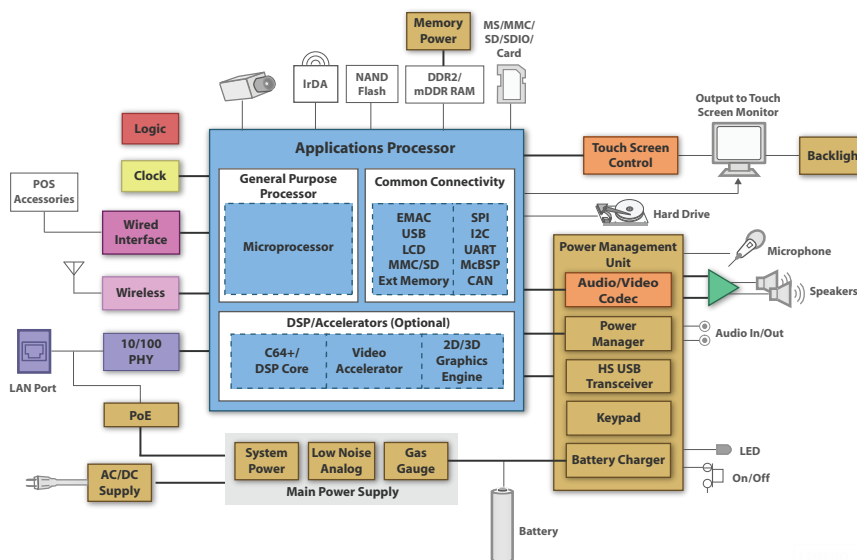**Embedded Processing:** TI's processing and control solutions offer a breadth of performance, key industrial peripherals, and robust software development kits to enable product family scalability, value through integration, and fast time to market. TI's ARM® Cortex™-M MCUs are perfect for the entry-level tier of the HMI market supporting up to WVGA displays, simple user interfaces and key industrial connectivity options. TI's scalable 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 drive down system cost and expand connectivity options.

To make development easier, TI supports a wide variety of **operating systems (OS),** such as Linux™, Windows® CE and Android™, as well as multiple real-time operating systems like QNX® and VXWorks®.

Power Management: TI provides **power management units (PMU)**, specifically matched with corresponding processors as well as other solutions to deliver power such as DC-DC controllers, **Low Drop Out regulators (LDO), Power over Ethernet** devices, **LCD bias** (to deliver power to your display) and **backlighting** solutions such as white LED drivers.

Wired connectivity: TI has solutions to enable **wired connectivity** by communication standards such as CAN, UART, USB, RS-232, RS-485 and 10-/100-Mbit Ethernet. These **interface** options enable hooking up the system to a myriad of external

peripherals and accessories, depending on the need of the end application. Real-time communications is the heart of industrial automation. With a unique architecture of an ARM processor and Programmable Real-Time Unit and Industrial Communication Subsystem (PRU-ICSS), TI integrates popular serial and Ethernet-based standards such as PROFIBUS®, CANopen®, DeviceNET, EtherCAT®, PROFINET®, EtherNet/IP™, Modbus TCP/IP, SERCOS® and POWERLINK.

Wireless connectivity: TI solutions for *Bluetooth*®, ZigBee®, Sub-1 GHz and WLAN networks enable portable HMI solutions. TI's broad portfolio

provides more options for maximum flexibility in wireless design. TI's **WiLink™ 8 solutions** can can provide high-performance Wi-Fi® and *Bluetooth/Bluetooth* low energy in one combo module, and TI's SimpleLink™ CC3000 module is an option for easy-to-integrate Wi-Fi. The Sub-1 GHz Performance Line delivers the most reliable range and best coexistence in the industry and the CC253x ZigBee Wireless Microcontrollers and royalty-free ZigBee z-stack software are the ideal solutions for mesh networking applications. Learn more at **www.ti.com/wireless**.

Embedded Processing Solutions for HMI

Description	Device	Key Benefits

Sitara™ processors with ARM Cortex-A8 core	**AM335x**	• Flexibility for scalable display resolutions including VGA, SVGA, XGA, 720p, WXGA, WUXGA (AM5x)
		• High-performance 2D/3D graphics engine capable of up to 30 million triangles/sec
		• Enables high-level operating systems and real-time operating systems
		• Scalable solutions integrate key industrial protocols including:
		  ○ EtherCAT®
		  ○ PROFIBUS®
		  ○ POWERLINK

Sitara™ processors with ARM Cortex-A9 core	**AM4x**	○ EtherNet/IP™ ○ PROFINET®

Sitara™ processors with ARM Cortex-A15 core	**AM5x**	○ SERCOS® III
		  ○ CANopen®
		  ○ And more

Tiva™ C Series with ARM Cortex-M	**TM4C129x**	• Up to 120 MHz • Up to WVGA via integrated LCD controller with touch-screen support • Networking – Integrated 10/100 Ethernet MAC and PHY • Connectivity – I²C, CAN, USB, UART, quad SPI and TI wireless solutions • Full-featured graphics library and examples provided by Texas Instruments • Temperature range from –40°C to 105°C
Tiva C Series with ARM Cortex-M	**TM4C123x**	• Up to 80 MHz • Up to WVGA via external LCD external controller • I²C, CAN, USB, UART, quad SPI and wireless • Full-featured graphics library and examples provided by Texas Instruments • Temperature range from –40°C to 105°C

Ethernet PHY

Part Number	Description	Interface	Cable Length (m)	LED (#)	Supply Voltage (V)	Datarate (Mbps)	JTAG 1149.1	Port Count	Special Features	Operating Temperature Range (°C)	Pin/Package	Price* (US$)
TLK110	Industrial 10/100 Ethernet PHY	MII, RMII	150	3	3.3	10/100	Yes	Single	Deterministic delay, Programmable fast link down modes, Cable diagnostics	–40 to 85	48/LQFP	2.20
TLK105	Industrial temp, single-port 10/100Mbs Ethernet physical layer transceiver	MII, RMII	150	1	3.3	10/100	No	Single	Deterministic delay, Programmable fast link down modes	–40 to 85	32/VQFN	0.99
TLK105L	TLK105L, TLK106L industrial temp, single-port 10/100Mbs Ethernet physical layer	MII, RMII	150	2	3.3	10/100	No	Single	Deterministic delay, Programmable fast link down modes, Cable diagnostics, FX support	–40 to 85	32/VQFN	Preview
TLK106	Industrial temp, single-port 10/100Mbs Ethernet physical layer transceiver	MII, RMII	150	1	3.3	10/100	No	Single	Deterministic delay, Programmable fast link down modes, Cable diagnostics	–40 to 105	32VQFN	1.19
TLK106L	TLK105L, TLK106L industrial temp, single-port 10/100Mbs Ethernet physical layer	MII, RMII	150	2	3.3	10/100	No	Single	Deterministic delay, Programmable fast link down modes, Cable diagnostics, FX support	–40 to 105	32/VQFN	Preview

Industrial Interface Transceivers

Part Number	Description	Bus Fault Voltage (V)	ICC (Max) (mA)	Number of Nodes	Date Rate	Duplex	ESD	Supply Voltage(s) (V)	Special Features	Operating Temperature Range (°C)	Pin/Package	Price* (US$)
SN65HVD257	CAN transceiver with fast loop times for highly loaded networks and features for functional safety	−27 to 40	85		10kbps to 1Mbps	Half	±12 kV HBM protection	4.5 to 5.5	High-speed, Turbo short prop delay, Redundancy and functional safety	−40 to 125	8/SOIC	0.60
SN65HVD888	Bus-polarity correcting RS-485 transceiver with IEC-ESD protection	−18 to 18	0.9	256	300bps to 250kbps	Half	±16 kV HBM protection, ±12 kV IEC61000-4-2 contact discharge, +4 kV IEC61000-4-4 fast transient burst	4.5 to 5.5	Bus-polarity correction within 76ms (tFS), Exceeds requirements of EIA-485 Standard	−40 to 85	8/SOIC	1.10

Isolated Industrial Interface

Part Number	Description	Integrated Transformer Driver	Duplex	Isolation Rating (kVrms)	VCC1 (Min) (V)	VCC1 (Max) (V)	VCC2 (Min) (V)	VCC2 (Max) (V)	Datarate (Mbps)	Number of Nodes	ESD (kV)	Fail Safe	Operating Temperature Range (°C)	Pin/Package	Price* (US$)
ISO1176	Isolated PROFIBUS® RS-485 transceiver	No	Half	2.5	3.15	5.5	4.75	5.25	40	256	16	Idle, Open, Short	−40 to 85	16/SOIC	3.00
ISO1050	Isolated 5-V CAN transceivers	No	Half	2.5, 5	3	5.5	4.75	5.25	1		4	Idle, Open, Short	−55 to 105	16/SOIC, 8/SOP	1.55

Digital Isolators

Part Number	Description	Isolation Rating (kVrms)	Peak Isolation Rating (Vpk)	Working Voltage (Vpk)	Forward / Reverse Channels	Speed (Max) (Mbps)	VCC (Min) (V)	VCC (Max) (V)	Default Output	Propagation Delay (Typ) (ns)	Operating Temperature Range (°C)	Pin/Package	Price* (US$)
ISO7420	Low-power dual-channel isolators	2500	4000	560	2/0	1	3.3	5	High	9	−40 to 105	8/SOIC	0.85
ISO7420FCC	Low-power 2/0 dual-channel digital isolator with fail-safe output low and noise filter	2500	4000	560	2/0	50	3.3	5	Low	20	−40 to 85	8/SOIC	1.05
ISO7141FCC	4242-VPK Small-footprint and low-power 3/1 quad-channel digital isolator with fail-safe output low	2500	4000	560	3 / 1	50	2.7	5	Low	23	−40 to 125	16/SOIC	1.90

Temperature Sensors

Part Number	Description	Operating Temperature Range (°C)	Local Sensor Accuracy (Max)(± C)	Temp Range for Listed Accuracy (°C)	Infrared Sensor Accuracy (Max) (± C)	Temp Resolution (Max) (bits)	Supply Current (Typ) (µA)	Supply Voltage (Min) (V)	Supply Voltage (Max) (V)	Interface	Programmable Alert	Shutdown	Pin/Package	Price* (US$)
TMP112	High-precision, low-power, digital temperature sensor	−40 to 125	0.5	0 to 65	–	12	7	1.4	3.6	I²C, SMBus	Yes	Yes	6/SOT	0.80
TMP006	Digital local and infrared thermopile sensor in ultra-small chipscale package	−40 to 125	1	0 to 60	3	14	240	2.2	5.5	I²C, SMBus	No	Yes	8/DSBGA	1.50
LM57	High-accuracy, low-power analog temperature sensor and switch	−50 to 150	0.7	−50 to 150	–	–	24	2.4	5.5	Analog	Supply pin	No	8/WSON	0.65
LMT86	Value for performance analog temp sensor	−50 to 150	2.7	−50 to 150	–	–	5.4A	2.2	5.5	Analog	Supply pin	No	SC70-5	0.195

Window Comparator

Part Number	Description	Vs (Min) (V)	Vs (Max) (V)	tRESP Low-to-High (µs)	Vos (Offset Voltage @ 25°C) (Max) (mV)	Iq per Channel (Max) (mA)	Output Type	Input Bias Current (±) (Max) (nA)	Number of Channels	Special Features	Rail-Rail	Operating Temperature Range (°C)	Pin/Package	Price* (US$)
TPS3700	High-voltage (18V) window comparator with over- and undervoltage detection	1.8	18	29	5.5	0.013	Open drain	25	1	Hysteresis, Internal reference, Window comparator	In	−40 to 125	6/SOT, 6/WSON	0.70

Supply Voltage Supervisor

Part Number	Description	# of Supplies Monitored	Threshold Voltages (Typ) (V)	VCC (Min) (V)	VCC (Max) (V)	Iq (Typ) (µA)	Output Driver Type / Reset Output	Reset Threshold Accuracy (%)	Watchdog Timer WDI (sec)	Time Delay (ms)	Special Features	Operating Temperature Range(C)	Pin/ Package	Price* (US$)
TPS386000	Quad supply voltage supervisors with programmable delay and watchdog timer	4	0.4	1.8	6.5	12	Active-low, Open-drain	1	0.45	20, 300, Programmable	Manual reset, Negative voltage monitoring, Over voltage sense, Programmable delay	−40 to 125	20/QFN	0.95

DC-DC Regulators

Part Number	Description	Vin (Min) (V)	Vin (Max) (V)	Vout (Min) (V)	Vout (Max) (V)	Iout (A)	Topology	Switch Current Limit (Typ) (A)	Iq (Typ) (mA)	Duty Cycle (Max) (%)	Soft Start	Compensation	Special Features	Operating Temperature Range (°C)	Pin/ Package	Price* (US$)
TPS55340	Integrated, 5-A 40-V wide input range boost/SEPIC/Flyback DC-DC converter	2.9	32	3	38	3	Boost, SEPIC, Flyback	6	0.5	90	Adjustable	External	Enable, Frequency synchronization, Power good	−40 to 125	14/HTSSOP, 16/WQFN	1.85
TPS40210	Wide input range current mode boost controller	4.5	52	5	260	6	Boost	NA	1.5	95	Adjustable	Internal	Enable, Frequency synchronization	−40 to 125	10/MSOP-PowerPAD, 10/SON	0.80
TPS62150	3–17V 1A step-down converter with DCS-Control™	3	17	0.9	6.3	1	Buck, Synchronous buck	1.7	0.017	100	Adjustable	Internal	Enable, Light load efficiency, Power good, Tracking, Voltage margining	−40 to 85	16/QFN	0.98
TPS54160A	3.5V to 60V input, 1.5A step-down converter with Eco-mode™	3.5	60	0.8	58	1.5	Buck, Inverting buck-boost	1.8	0.116	98	Adjustable	External	Enable, Frequency synchronization, Light load efficiency, Power good, Tracking	−40 to 150	10/MSOP-PowerPAD, 10/SON	1.58
TPS54061	4.7 to 60V Input, 200mA Synchronous Step-Down Converter	4.7	60	0.8	58	0.2	Buck, Inverting buck-boost	0.35	0.09	98	Fixed	External	Adjustable UVLO, Enable, Frequency Synchronization, Light Load Efficiency, Synchronous Rectification	−40 to 150	8/SON	1.04
TPS54361	4.5 to 60V Input, 3.5A Step-Down Converter	4.6	60	0.8	59	3.5	Buck	5.5	0.152	98	Adjustable	External	Enable, Frequency Synchronization, Light Load Efficiency, Power Good, Tracking, Adjustable UVLO	−40 to 150	10/WSON	2.60
LM5017	100V, 600mA constant on-time synchronous buck regulator	9	100	1.25	90	0.6	Constant on-time synchronous buck	1.3	1.75	90	External	No compensation needed	Intelligent current limit, primary-side fly-buck regulation	−40 to 125	8/SO PowerPAD, 8/WSON	1.57

Suggested resale price in U.S. dollars in quantities of 1,000.

LDO Linear Regulators

Part Number	Description	Output Options	Iout (Max) (A)	Vin (Min) (V)	Vin (Max) (V)	Vout (Min) (V)	Vout (Max) (V)	Iq (Typ) (mA)	Vdo (Typ) (mV)	Additional Features	Operating Temperature Range (°C)	Pin/ Package	Price* (US$)
TLV700	200mA, low IQ, low dropout regulator	Fixed 1.2V, 1.3V, 1.5V, 1.8V, 1.9V, 2.2V, 2.5V, 2.8V, 2.9V, 3.0V, 3.1V, 3.2V, 3.3V, 3.6V	0.2	2	5.5	Fixed outputs	Fixed outputs	0.03	175	Enable, over current protection, thermal shutdown	−40 to 125	5/SC-70, 5/SOT, 6/WSON	0.13
TLV704	24V, 150mA, ultra-low IQ, high Vin low-dropout regulator	Fixed 3.0V, 3.3V, 3.6V, 5.0V	0.15	2.5	24	Fixed outputs	Fixed outputs	0.003	400	Stable with any capacitor (> 0.47 µF), over current protection	−40 to 125	5/SOT	0.25

Power Management Units

Part Number	Description	Regulated Outputs (#)	Vin (Min) (V)	Vin (Max) (V)	LDO	Step-Up DC/DC Converter	Step-Down DC/DC Converter	Iout (Max) (A)	Operating Temperature Range (°C)	Pin/ Package	Price* (US$)
TPS650250	Integrated power management IC w/ 3 DC/DCs and 3 LDOs in 5×5mm QFN	6	2.5	6	3	–	3	1.6	−40 to 85	32 VQFN	2.20
TPS65910A	Integrated power management IC w/ 4 DC/DCs, 8 LDOs and RTC in 6×6mm QFN	11	2.7	5.5	9	1	3	1.7	−40 to 85	48 VQFN	3.45
TPS65217	Single-chip PMIC for battery-powered systems for AM335x ZCE/ZCZ, DDR2	7	2.7	5.8	4	–	3	1.2	−40 to 105	48 VQFN	3.45

DDR termination

Device	VIN (V)	Vbias (V)	Iout Max VTT (A)	Iout Max VDDQ (A)	DDR Memory Type	DDR Voltages	Regulator type	Pin/Package	"Price*	Price* (US$)
TPS51216	3 to 28	4.5 - 5.5	2	25	DDR,DDR2,DDR3,DDR3L,DDR4,LPDDR2,LPDDR3	VDDQ, VTT, VTTREF	Controller + Linear	20/QFN	1.00	2.20
TPS51206	VTT+0.4V to 3.5	N/A	2	N/A	DDR2,DDR3,DDR3L,DDR4,LPDDR2,LPDDR3	VTT, VTTREF	Linear	10/SON	0.70	3.45
TPS51200	1.1 to 3.5	4.5 to 5.5	3	N/A	DDR,DDR2,DDR3,DDR3L,DDR4,LPDDR2,LPDDR3	VTT, VTTREF	Linear	10V/SON	0.75	3.45

Connectivity Wifi and *Bluetooth*®

Part Number	Device Type	Description	Freq (Hz)	Processor Integration	Flash	RAM	Security	Over the Air Upgrade	Peripherals	ADC	Data rate (Kbps)	Temp Range (C)
CC2530	Wireless MCU	ZigBee Wireless MCU	2.4G	8051	Up to 256KB	8KB	AES	No	SPI; UART	12-bit, 8-ch	250	-40 to 125
CC2531	Wireless MCU	ZigBee Wireless MCU with USB	2.4G	8051	Up to 256KB	8KB	AES	No	USB; SPI; UART	12-bit, 8-ch	250	-40 to 125
CC2538	Wireless MCU	Performance ZigBee Wireless MCU	2.4G	ARM Cortex M3	Up to 512KB	Up to 32KB	AES 128/256; SHA2; ECC-128/256; RSA	Yes	USB; I2C; SSI; SPI; UART	12-bit, 8-ch	250	-40 to 125
CC2592	Range Extender	2.4GHz Range Extender +22dBm output power	2.4G	-	-	-	-	-	-	-	-	-40 to 125
CC2590	Range Extender	2.4GHz Range Extender +14dBm output power	2.4G	-	-	-	-	-	-	-	-	-40 to 85

Power over Ethernet

Part Number	Description	PoE Standards Supported	PD Power Level	PoE Inrush Limit (Typ) (mA)	PoE Current Limit (Min) (mA)	UVLO	rDS(on) per FET (Typ) (mOhms)	Fault Response	Error Amplifier	Auxiliary/Local Power Support	Auxiliary Power Rails Supported	Duty Cycle (%)	Switching Frequency	Pin/Package	Price* (US$)
TPS2379	IEEE 802.3at PoE high-power PD interface with external gate driver	802.3at type 2	External circuit	140	850	802.3at type 1/type 2	420	Auto retry	No	No	N/A		N/A	8/SO PowerPAD	1.00
TPS2378	IEEE 802.3at PoE high-power PD interface with AUX control	802.3at type 2	25W	140	850	802.3at type 1/type 2	420	Auto retry	No	Yes	Yes		N/A	8/SO PowerPAD	1.00
TPS23753A	IEEE 802.3-2005 PoE interface and isolated converter controller with enhanced ESD ride-through	802.3at type1	13W	140	405	Unified	700	Auto retry	No	Programmable	12V-57V	78	Programmable, Synchronizable	14/TSSOP	1.10
TPS23754-1	IEEE 802.3at PoE Interface and Isolated Converter Controller	802.3at type1, 2	25W	140	850	Unified	430	Auto retry	No	Programmable	24V-57V	78	Programmable, Synchronizable	20/HTSSOP	1.25

*Suggested resale price in U.S. dollars in quantities of 1,000.

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TEXAS INSTRUMENTS

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