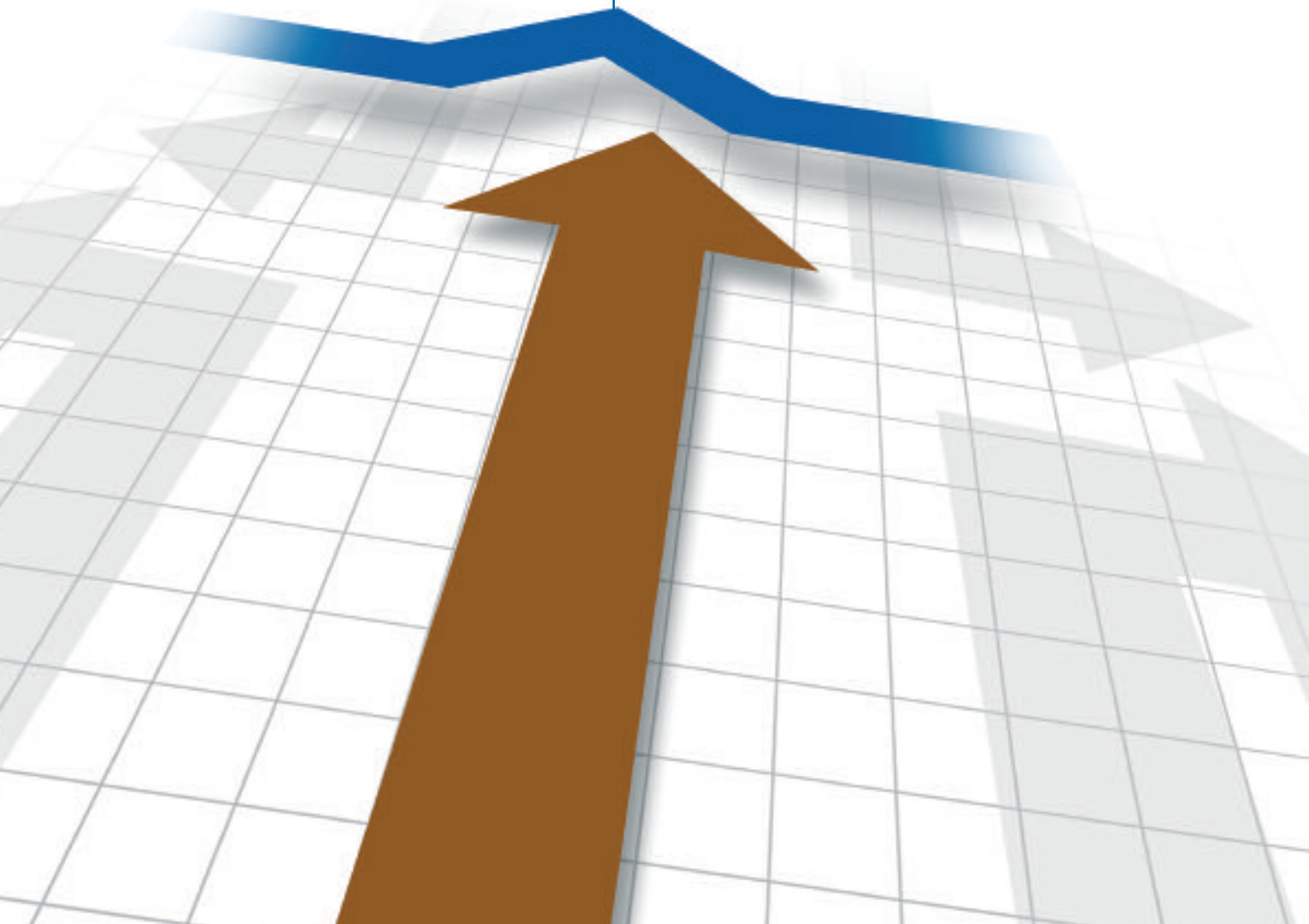
8 chapter
Human-machine interface

Presentation :

- *Man machine dialog according to machine operation*
- *Command and interface solutions (push buttons or terminals)*
- *Screens configuration software*



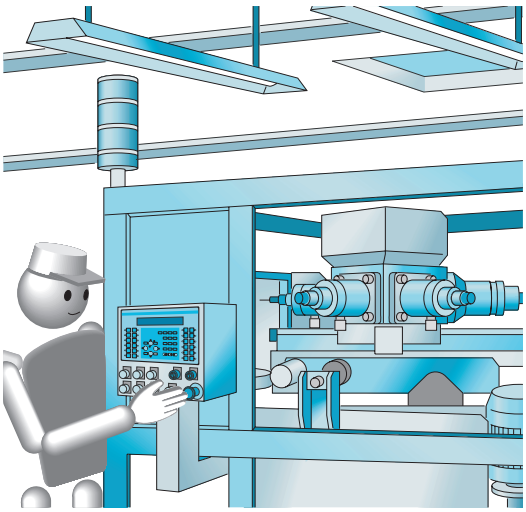
8. Human-machine interface

Summary

8. Human-machine interface

Operators play an important part in the human-machine dialogue. They must use the information they have to perform actions that make the machines and installations run properly without endangering safety and availability. It is therefore crucial that the interfaces and dialogue functions are designed to ensure that operations can be performed reliably in all circumstances.

8.1 Human-machine interface setup



↑ *Fig. 1* *Human machine interface*

■ Information flow in the human-machine interface

A human-machine interface *(⇨ Fig. 1)* uses two information flows in two directions:

- Machine –> Human
- Human –> Machine

These flows are independent yet linked.

□ Independent

Because their content can be on different levels.

The levels are defined by the designer of the automation system according to the requirements of the process and what the user wants, such as discrete signals from the operator to the machine, alphanumerical or animated diagram messages from the machine to the operator.

□ Linked

Because the automation system interprets an operator action on a control interface as a specifically defined action and, in return, emits information that depends on whether the action was properly performed or not. The operator can either act by his own decision (stop production, modify data, etc.) or in response to a message from the machine (alarm, end of cycle, etc.).

■ Role of the operator

The operating interface includes all the functions required for controlling and supervising the operation of a machine or installation.

Depending on the requirements and complexity of the process, the operator may have to perform.

□ Regular process run tasks

- stop and start the process; both steps may include start and stop procedures that are automatic or manual or semi-automatic and controlled by the operator;
- operate the controls and make the adjustments required for regular process run and monitor its progress.

□ Tasks to deal with unexpected events

- detect abnormal situations and undertake corrective action before the situation disturbs the process further (e.g. for early warning of motor overload, restoring normal load conditions before the overload relay trips);
- deal with system failure by stopping production or implementing downgraded operation using manual controls instead of automatic ones to keep production running;
- ensure safety of people and property by operating safety devices if necessary.

The scope of these tasks shows how important the operator's role is. Depending on the information he has, he may have to take decisions and perform actions that fall outside the framework of the regular procedures and directly influence the safety and availability of the installation. This means the dialogue system should not be confined to mere exchange of information between human and machine but should be designed to facilitate the task of the operator and ensure that the safety of the system in all circumstances.

Quality of interface design

The quality of the operating interface design can be measured by the ease with which an operator can **detect and understand** an event and how efficiently he can **respond**.

Detect

Any change in a machine's operating conditions is usually seen by a change in or display of information on an indicator, display unit or screen. The operator must, above all, be able to detect the event in any environmental conditions (ambient lighting, etc.).

Different means can be employed to attract attention: flashing information, colour change, sound signal, anti-reflection devices, etc.

Understand

To prevent any action that might endanger safety, the information the operator sees must be legible and accurate enough to be immediately understood and used.

This is as much a matter of the ergonomics of the components as of the function design:

- for a pilot light: use of the standard colour, fast and slow flashing clearly differentiated, etc.;
- for a display unit: clear texts in the language of the user, adequate reading distance, etc.;
- for a screen: use of standard symbols, zoom giving a detailed view of the area the message involves, etc.

Respond

Depending on what message the machine sends, the operator may have to act swiftly by pressing one or more buttons or keys. This action is facilitated by:

- clear markings to identify buttons and keys easily, such as standard symbols on buttons;
- clever ergonomics with large buttons, touch keys, etc.

8. Human-machine interface

8.2 Human-machine interfaces

The human-machine interface has made outstanding progress over the last few years. The basic function of the push button has been enhanced by interfaces using electronics to improve and customise the dialogue and add new features, such as custom settings and diagnostics.

The table *(⇨ Fig. 2)* shows the offer and functions of human-machine interfaces

	DESIGN	COMMISSIONING	OPERATING	MAINTENANCE
Product				
PB		YES	YES	YES
Integrated dialogue		YES	YES	YES
Operator Dialogue	CAD software	YES	YES	Possible
Supervision	CAD software	YES	YES	Possible
Function				
Operation		PB, Supervision, Operator dialogue	PB, Supervision, Operator dialogue	
Diagnostic				Integrated dialogue (Supervision and Operator dialogue possible)
Adjustment			Integrated dialogue (Supervision and Operator dialogue possible)	
CAD software and others	Integrated dialogue Operator, Supervision software			PC adjustment software

Fig. 2 *Offer and functions of human machine interfaces*

8.3 Discrete control and indicator units

■ Push buttons and pilot lights

□ Standard ranges

These interfaces are perfectly adapted to situations where the operator and the machine exchange little information which is limited to discrete signals (run orders and status indications).

They are rugged and reliable electromechanical components that are easy to implement, ergonomic and not vulnerable to ambient conditions. They can be fitted with a wide range of round or square control heads.

They have a standard colour code which makes them easy to identify (see note).

They are intuitive or reflex devices (e.g. for emergency stops).

For this reason, they are used for safety operations which require controls that are as simple and direct as possible.

ϕ 16mm ϕ 22mm ϕ 30mm

Fig. 3 *Push buttons Harmony design*

Note : the IEC 60204-1 standard stipulates the colour codes that pilot lights and push buttons must be:

- *red light: emergency – hazardous situation requiring immediate action (pressure not within safety limits, over-travel, broken coupling, etc.);*
- *yellow light: abnormal – an abnormal situation likely to lead to a hazardous situation (pressure not within normal limits, tripping of protection device, etc.);*
- *white light: neutral – general information (supply voltage, etc.);*
- *red push button: emergency - action to counter danger (emergency stop, etc.);*
- *yellow push button: abnormal - action to counter abnormal conditions (intervention to restore an automatic cycle run, etc.).*

The push button interface is used for general stop and start control and safety circuit control (emergency stops).

They exist in diameters of 16, 22 and 30mm (NEMA standards) and different designs *(⇨ Fig 3)*:

- chromium-plated metal bezel, for all heavy-duty applications in harsh industrial environments;
- plastic for harsh environments: chemical and food industries.

• **Operating head**

There is a wide range of control heads:

- flush, protruding, recessed or booted;
- mushroom;
- double-headed;
- mushroom with latching;
- “emergency stop”;
- switch with toggle, handle, key, 2 or 3 set or pull-off positions;
- metal pin (multidirectional control);
- flush, protruding or booted pilot lights.

The modular design of control and indicator units offers great flexibility of use.

Pilot lights and illuminated buttons are fitted with filament lamps or LEDs. They are mains powered and have a voltage reducer or built-in transformer.

The control units can hold 1 to 6 NO or NC contacts compatible with 24V PLC inputs.

• **Ruggedness and reliability**

Push buttons and pilot lights are subject to harsh environmental conditions. Life time of a push button is around 1 million of operations. They must be designed to withstand shock tests according to the IEC 60947-5-5 standard. As an example, according to the standard, an emergency stop button must withstand 5.5 Joules without failure, the Harmony push button range can withstand 17 Joules.

□ Buttons and pilot lights for printed circuit connection *(⇨ Fig. 4)*

The 22mm diameter range exists in a version for "printed circuit connection". These products are designed for repeated dialogue media with an identical diagram. The control and indicator units are from the standard range. The electrical blocks specific to these versions have output contacts to weld them to printed circuits.

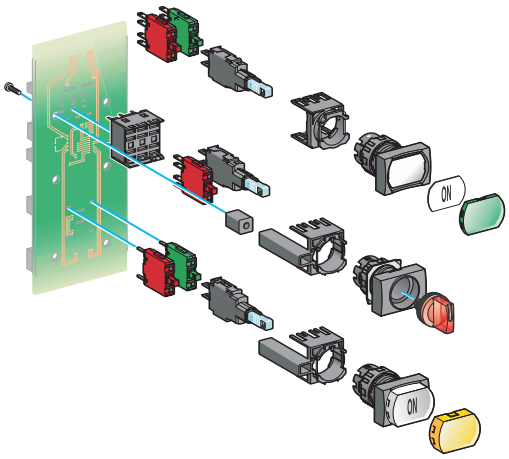
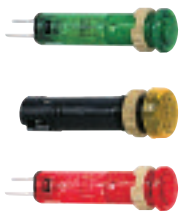


Fig. 4 *Push button and pilot light for printed circuit board*



↑ Fig. 5 *Led's pilot lights*

- **Square-headed key buttons and pilot lights**

These devices are mounted at intervals of 19,05 mm (3/4 ") in holes 16 mm in diameter. They are used to make compact control units when space is at a premium and they can be linked to input keyboards.

Key buttons are touch-sensitive. They can have a silver or gold contact.

- **LED pilot lights** *(⇨ Fig 5)*

LED's for 0.8 and 12 mm mountings are especially recommended when space is limited or when there are a lot of indicating elements (low power dissipation).
They have many advantages:
- excellent resistance to shocks, vibrations and voltage surges,
- long lifetime (>100,000 hrs),
- low consumption making them directly compatible with PLC's outputs.

□ Illuminated beacons and banks *(⇨ Fig. 6)*

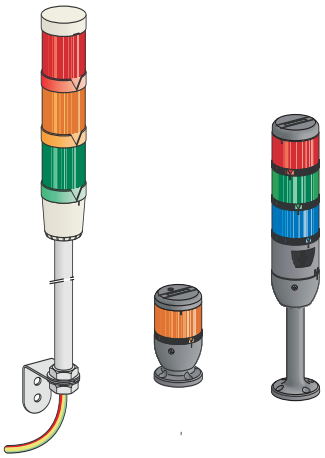
Beacons and banks are optical or sound indicators to view machine and alarm statuses over great distances and through 360°.

- **Beacons**

These have a single illuminated lens or flash unit, which is colourless, green, red, orange or blue.

- **Banks**

These have a variable composition made up of lens units, flash units or sound signals. These elements are slotted together. Electrical connection is made automatically as they are stacked together.



↑ Fig. 6 *Illuminated beacons and banks*

- **IEC 60204-1 standard**

The IEC 60204-1 standard stipulates the colour codes corresponding to displayed messages :

Light signalling
- Red: urgent (immediate action required)
- Yellow / Orange: anomaly (checking and/or intervention required)
- Green: normal condition (optional)
- Blue: obligatory action (action required from the operator)
- White: monitoring (optional)

Flashing lights
- For distinction or specific information:
- Attract more attention
- Call for immediate action
- Indicate discordance between the instruction and the actual status
- Indicate a change in cycle (flashing during transition).

Flash and rotating mirror beacons
- A more powerful signal for top priority information or longer distance signalling (conforming to IEC 60073).

Buzzer and sirens
- Recommended in environments subject to considerable light or sound interference or when the presence of the operator is of higher importance.

↑ Fig. 7 *Telemecanique joysticks*

□ Joysticks *(⇨ Fig. 7)*

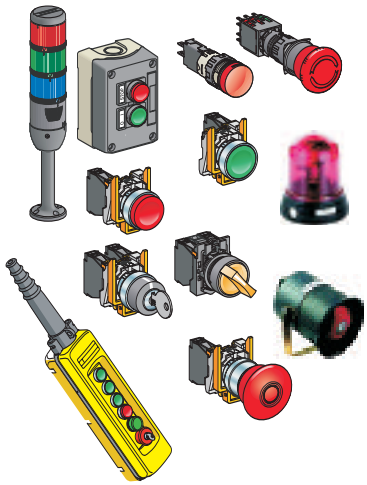
Joysticks usually use contactors to control movement through one or two axes, such as travel/direction or raising/lowering on small hoisting equipment.

They usually have 2 to 8 directions, with 1 or 2 contacts per direction, with or without return to zero.

Some joysticks have a "dead man" contact at the end of the lever.

8. Human-machine interface

8.4 Schneider Electric Discrete Control and Indicator Unit offer



↑ *Fig. 8* *Harmony offer*

■ Harmony range (Telemecanique)

The illustration above shows part of the Harmony range of discrete control and indicator units. These products are noted for their:

- **simplicity:** the elements clip together for safe and easy assembly;
- **ingenuity:** LED technology used for all light functions;
- **flexibility:** modular design to upgrade the products along with the automation system;
- **ruggedness:** mechanical performances well above standard;
- **compactness:** overall dimensions are the smallest on the market;
- **multiple connection options:** 2.8 x 0.5 Faston lugs, welded lugs, tags, screw-in terminals or terminal clamps.

8.5 Advanced human-machine interfaces

Progress in electronics and communication systems has led to the development of human-machine interfaces with enhanced user-friendly functions.

These interfaces make it possible to set product parameters, obtain information on actuators, such as current consumption, temperature, speed, etc.

The operator can also choose the working language by setting it in advance.

↑ *Fig. 9* *ATV71 embendded control panel*

■ Special embedded control panel

Special dialogue tools built into products offer performance tailored to the needs of operating adjustment and efficient diagnostics.

The panel *(⇨ Fig. 9)* is from an **Altivar ATV 71** Telemecanique.

□ Main features

- Graphic screen with custom display.
- Plain text entry with 6 languages available (Chinese, English, French, German, Italian and Spanish) and others on option.
- Browse button to navigate the menus easily.
- “Simply Start” menu for a quick start to get the most from Altivar 71 performance immediately.
- “Function” keys for shortcuts, online help or to configure for applications.
- Permanent display of motor operation settings.

□ Main advantages

- **Clear** display with text on 8 lines and graphic views. Legibility up to 5 m *(⇨ Fig. 10)*.
- **Flexibility** through remote operation: on a cabinet door avec with IP 54 or IP 65 protection for multipoint connection to several speed controllers.
- **Storage** 4 configurations can be stored for transfer to other speed controllers.

↑ *Fig. 10* *Example of ATV71 messages*

8

- **Ease to use** with function keys for shortcuts, direct access and online help, maximum and minimum parameter display.
- **Ergonomic** browse button. Navigate the dropdown menu quickly and easily with just one finger.
- **Custom** parameters, viewing screens, monitor bar, user menu creation, etc.
- **Protection** of parameters, visibility control, password protection for safe and easy access to custom configurations.

Many macro-configurations already integrated. They ared designed for a wide range of uses and applications: handling, hoisting, general use, connection to field bus, PID regulation, master, slave, etc.

They are easy to modify.

A wealth of varied services is available through the graphic terminal to help tune and diagnose machines.

■ Screen/keyboard terminals

Unlike embedded terminals, screens and keyboards are generic products that adapt to any application.

As we saw in the table above *(⇨ Fig. 2)*, screen terminals are used in both commissioning and operation.

Depending on their type and software, they can play an important part in maintenance operations.

Terminals communicate with the process via the appropriate communication bus and are an integral part of the dialogue and data chain.

To illustrate what screen/keyboard terminals can do, we shall take a look at the Telemecanique Magelis offer.

These graphic terminals (with an LCD touch screen of 5.7” to 12.1” and keyboard or touch screen of 10.4”) provide simple access to graphic solutions for controlling and/or supervising automated units. Communication performance are guaranteed by a direct connection to an Ethernet TCP/IP network.

□ Important features

- **Designed for harsh industrial environments**
  - rugged and compact;
  - reliable ergonomic control by keyboard or touch screen;
  - highly contrasted screens for excellent legibility.
- **Maintenance & diagnostics via the web**
  - remote control via Internet Explorer;
  - access to operator console diagnostic information via HTML pages;
  - remote diagnostics;
  - automatic emailing.
- **Compatible and upgradeable**
  - API connection available (several manufacturers);
  - OPC communication (several manufacturers (OPC server);
  - TCP/IP network integration;
  - Embedded VB Script.
- **Innovating HMI concepts**
  - decentralised control stations;
  - centralised access to local stations, small control rooms;
  - usable throughout the world over as many languages are supported.

XBT-F

XBT-G

↑ *Fig. 11* *Terminal device family*

Terminal device family *figure 11*.

Magelis XBT R, S
Compact matrix operator terminals:
- 4 to 8 lines with 5 to 20 prints,
- semi-graphic symbols,
- touch pad and password.

« ZENSHIN »
Touch screen graphic terminals available in 5.7 - 7.5 - 10.4" dimensions.

Magelis XBT GK
Graphic man machine operating terminals available in 5.7 - 7.5 - 10.4" dimensions.

Magelis XBT GT
Touch screen colour graphic terminals available in 3.8-5.7-7.4-10.4-12.1-15” dimensions.

- **Magelis XBT G touch screen graphic terminals**
  - **Display** LCD screen size 5.7” 7.4” 10.4” 12.1”
  - **Functions**
    - representation of variables: alphanumeric, bitmap, bargraph, gauge,
    - button, light, clock, flashing light, keypad;
    - curves with log;
    - incorporated alarm log.
  - **Communication**
    - embedded Ethernet: 10BASE-T (RJ45);
    - downloadable protocols: Uni-Telway, Modbus, Modbus TCP/IP.
  - **Compatible with Schneider Electric controllers and PLC’s:** Twido, Nano, Modicon TSX Micro, Modicon Premium, Modicon Quantum.
  - **Configuration software** Vijeo Designer **VJD SPU LFUCD V10M** (on Windows 2000 and XP).
  - **Compact Flash card slot**
  - **Supply voltage** 24V =
- **Magelis XBT F graphic terminals**
  - **Display** LCD screen size 10.4” Format 256-colour TFT
  - **Data entry keypad**
    - 10 dynamic function keys with LED’s;
    - 12 static function keys with LED’s + legends;
    - 12 service keys;
    - 12 alphanumeric keys + 3 alphanumeric access.

- **Touch screen data entry option**
- **Functions**
  - representation of variables: alphanumeric, bitmap, bargraph, gauge, potentiometer, selector;
  - recipes: 125 records maximum with 5000 values;
  - 16 curves;
  - alarm log.
- **Communication**
  - embedded Ethernet: 10BASE-T/100BASE-TX (RJ45);
  - buses and networks: Fipway, Modbus Plus, and third-party protocols;
  - downloadable protocols: Uni-Telway, Modbus, Modbus TCP/IP.
- **Compatible with Schneider Electric controllers and PLCs** Twido, Nano, Modicon TSX Micro, Modicon Premium, Modicon Quantum
- **Configuration software XBT L1003M** (on Windows 98, 2000 and XP)
- **Supply voltage** 24 V =

Industrial PC's

Characteristics

Industrial PC's are characterised by their rugged design enabling them to work without failure in industrial environments with electromagnetic interference and harsh climatic conditions. Industrial PC's can be compact or modular to fit closely the user's needs.

The illustrations *(⇨ Fig. 12a)* shows part of Schneider Electric offer.

	Magelis Smart i PC		Magelis Compact i PC		Magelis Modular i PC	Magelis i Display
						
Integrated scr een	12" SVGA	15" XGA	12" XGA	15" XGA	Without or 15" XGA	External screen 15" XGA*
Front panel interface	Touch screen		Touch screen		Touch screen and/or function keypad	Touch screen
	1 x USB	-	1 x USB	1 x USB	1 x PS2	-
Processor	Celeron M @600MHz	VIA @667MHz	Celeron M @1.3GHz	VIA @667MHz Pentium 4 M @1.7GHz	Celeron M @1.3GHz or Pentium M @1.6GHz	- -
Memory	CF 1GB		HDD 20 GB		HDD 40 GB	-
Reader	-	-	-	FDD, CDROM	FDD, CDROM, DVD-CD-Writer (Option)	-
Extension car ds	1 PCMCIA		1 PCI and 2 PCMCIA		1 or 4 PCI and 2 PCMCIA	-
Ethernet ports	2	1	2	1	1	-
Integrated video port					1	
Power supply	AC	DC	AC	AC	AC or DC	AC
Operating system	Windows XPe		Windows 2000 or XP Pro		Windows 2000 or XP Pro	
						* 12" and 19" available soon

↑ *Fig. 12a* *Partial Industrial Magelis PC offer*

Fig. 12b *Industrial modular PC - Magelis I Display*

Magelis Modular iPC industrial PCs

The modularity and flexibility of the Magelis Modular iPC range *(⇨ Fig. 12b)* offer solutions for the perfect choice of human-machine interface on a PC base, with easy upgrading and fast maintenance.

Magelis Modular iPC

Easy commissioning with 12” or 15” colour TFT LCD screens, with or without touch screen, with or without a QWERTY keyboard.

Magelis IDisplay

12, 15, 19” touch screen with a USB port optimising the man / machine interface.

8.6 Exchange modes

Conventional communication modes such as serial and bus links are naturally used on most products. They work through drivers embedded in the configuration software. Networks can also be used.

Protocols supported

All the core protocols in the =S= offer can be used:
- Uni-TE (Uni-Telway), Modbus, Modbus TCP-IP, FipWay, Modbus Plus;
- third-party protocols are also available;
- features: control graphic and ergonomics, types of automation system action.

FactoryCast (on PLC Ethernet plug-in) *(⇨ Fig. 13)*

Remote diagnostic functions via an ordinary internet browser:
- secure access to system diagnostics and application;
- numerical or graphic data display and adjustment;
- Emailing;
- open to customisation and web page creation for diagnostics suited to user needs.

Fig. 13 *Example of a remote diagnostic*

FactoryCast HMI

Same diagnostic functions as FactoryCast + new HMI functions embedded in a PLC module:
- real-time database and PLC data acquisition (1000 variables);
- calculations for pre-processing data;
- advanced alarm management with emailing;
- data archived in relational databases (SQL, Oracle, MySQL);
- a web server the user can customise for an interface suited to requirements.

FactoryCast Gateway

New offer of intelligent “all-in-one” web gateways in a standalone box containing:
- network communication interfaces and Modbus or Uni-Telway serial links;
- remote access server (RAS);
- alarm notification by email;
- a web function the user can customise.

8.7 Development software

In addition to the terminal hardware, software is also offered to configure and adapt the terminals to their requisite application.

Below is a description of the Telemecanique Magelis offer. Hardware and software are combined in a consistent package enabling the user to build the requisite application in the shortest possible time.

The software can also be used to communicate with third-party products to gain optimal flexibility and open-endedness.

XBT L1003M configuration software

For Magelis terminal displays running under Microsoft Windows 98, 2000 an XP.

The XBTL1001/L1003 configuration software is provided to build an interface in order to run or operate a machine. It is applicable to:
- all XBTN/R/H/HM displays, XBTP/PM/E screens with the XBTL1001 software;
- all XBTN/R/H/HM displays, XBTP/PM/E screens et F with the XBTL1003 software.

Application generated with the XBTL1001/L1003 software are independent of the protocol being uses. Same dialog application ca be used on PLC's coming from any major providers.

Configuration

The XBTL1001/L1003 configuration software is an user friendly package to create several family of pages:
- application pages (eventually linked to each other);
- alam pages;
- help pages;
- recipe pages.

Vijeo Designer, MMI interface software for XBTG / XBTGT

Vijeo Designer is a software workshop for the "Build Time" part and a run time software which is downloaded into the XBTG / XBTGT (⇨ Fig. 14).

The 'Build Time' part is similar to Visual Studio. The supported operating systems are Microsoft Windows 2000 et XP Professionnal.

The run time software, the key point of the solution is as user friendly as possible. It is available in two formats:
- a PC format which runs automatically any time a user wants to emulate the application on a PC;
- a user's format which can be downloaded in the background when debugging has bee made and the application is ready to run on the XBTG / XBTGT.

Additional information are available in the Schneider Electric documentation.

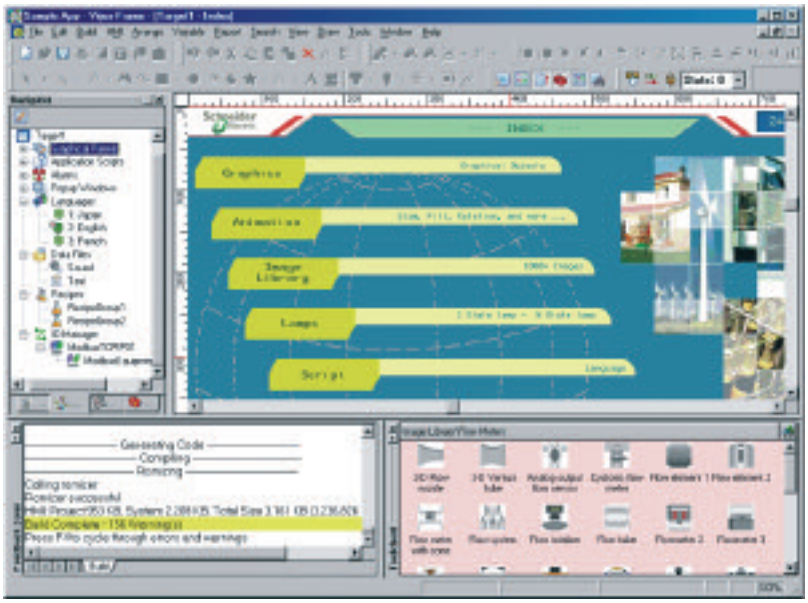


Fig. 15 Screen shot of Vijeo designer

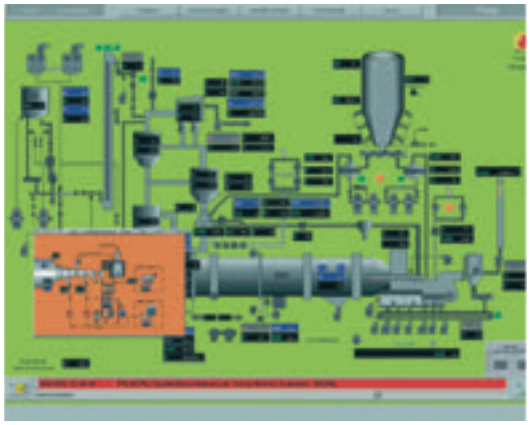


Fig. 14 Screen shot of Vijeo designer

Vijeo Citect

Vijeo Look 2.6 a SCADA (Supervision ControlAnd Data Acquisition) aimed to stand alone terminals *(⇨ Fig. 15)*. If offer a perfect symbiosis between Web and MMI (Man Machine Interface).

Information are available in the Schneider Electric documentation.

8.8 Conclusion

Human-machine interface is probably the sector in automation which has made the greatest progress in the last few years.

This progress is due to increasingly sophisticated and user-friendly electronics and signal processing.

With the right choice of interface and its configuration, users can control processes with ever greater exactness and undertake diagnostics and preventive maintenance to increase productivity by reducing downtime.