Modicon Quantum automation platform
Hot Standby system
Unity Pro

Presentation

The Hot Standby system is compatible with Unity Pro software, and provides Quantum CPUs with the high level of availability required by critical process applications, in terms of their control/command system.

At the center of the system are two Quantum PLC racks, commonly known as the “Normal” PLC and the “Standby” PLC. Their hardware configurations must be identical (same modules in each local rack). The key element, on each of them, is the 140 CPU 671 60 processor, specially designed for Hot Standby architectures with Unity Pro software. This processor is a double-slot module that combines the Central Processor Unit function with that of the redundant coprocessor in the same casing.

The “Normal” PLC executes the application program and controls the I/O. The “Standby” PLC stays in the background, ready to take over if necessary. The “Standby” PLC is connected to the “Normal” PLC via a high speed fiber optic link (100 Mbps) integrated in the CPU.
This fiber optic link (62.5/125 multimode) can be extended to 2 km without any additional special equipment. It is via this that the user application data is updated cyclically on the “Standby” PLC.

In the event of an unexpected failure affecting the “Normal” PLC, the standby system switches over automatically, changing execution of the application program and control of the I/O over to the Standby PLC, with an up-to-date data context. Once they have changed over, the “Standby” PLC becomes the “Normal” PLC. Once the faulty PLC has been repaired and reconnected to the standby system, it takes the role of the “Standby” PLC.

Using the Hot Standby system with Unity Pro software means a smooth changeover from normal to standby at the outputs. The changeover is transparent for the process, which will continue to be managed without any permanent ill-effects from the occurrence of a hardware failure. The Hot Standby system with Unity Pro software therefore increases productivity by minimizing downtime.

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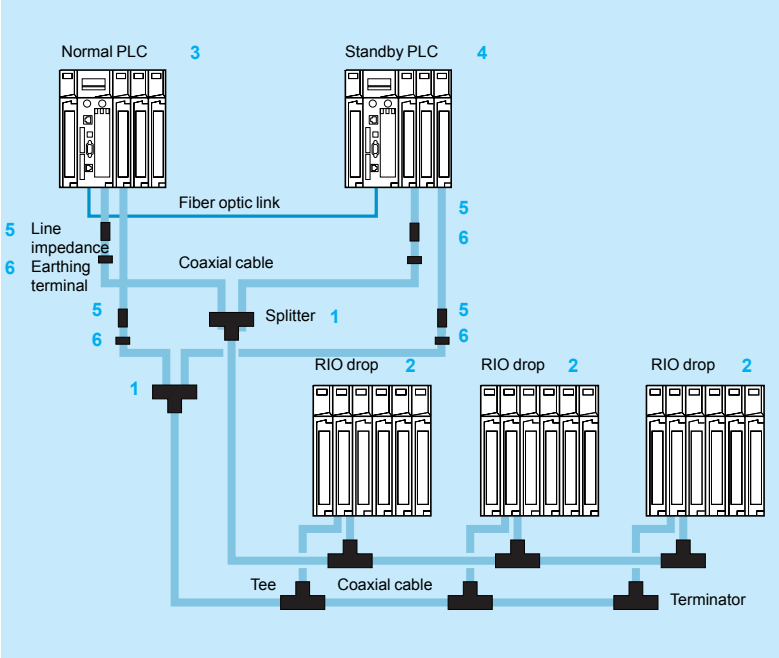
Architecture

Time-critical processes: remote I/O architecture (RIO)

For sensitive processes, requiring an I/O control takeover time within the region of the PLC scan time, an I/O architecture based on RIO (Remote I/O) native topology should be chosen by default.
These I/O drops, consisting of Quantum modules, are recognized and configured from the Unity Pro software programming environment. They benefit from scanning which is in synch with the scan time. A splitter box 1 (MA 0186 100) is used to exchange the RIO drop 2 I/O with the “Normal” 3 and “Standby” 4 PLCs. The line impedances 5 (990 XCA 656 09) can be used to maintain a suitable line when it is necessary to disconnect one of the I/O CPUs. The optional earthing terminals 6 (60 0545 000) are used to maintain the earthing of the coaxial cable in these conditions.
The availability of this I/O system can be reinforced by using a dual-medium I/O wiring system. It is possible to transpose these I/O drops on a (dual) optical ring, using optical transceivers.



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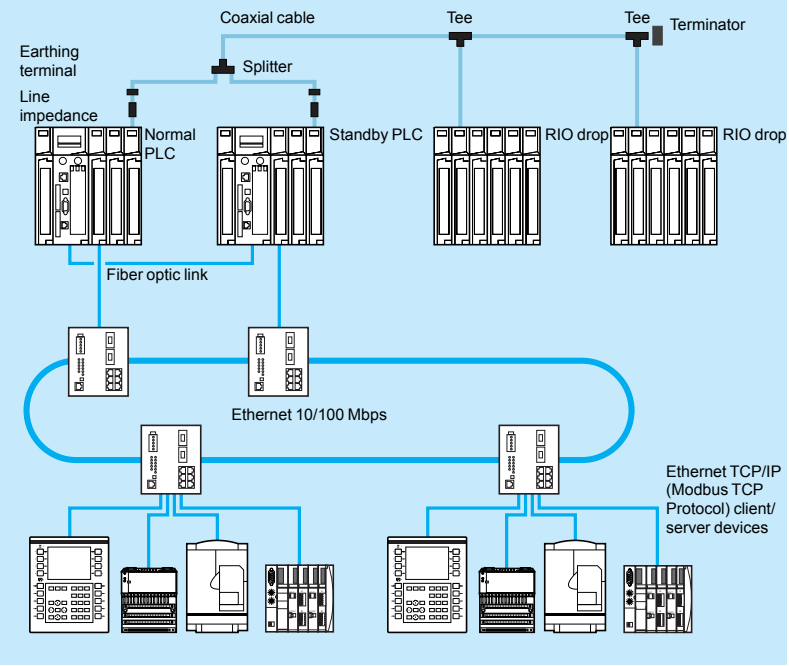
Architecture (continued)

Non time-critical processes: mixed architecture

For processes where times are less critical, from the point of view of the delay in controlling the I/O, it is possible to adopt a mixed architecture, combining both distribution of RIO type I/O (Remote I/O) on at least one drop and distribution of devices on Ethernet TCP/IP.

From an operational point of view, client type devices (PLC modules, Human-Machine interfaces, etc), and Modbus TCP server type devices (Momentum I/O blocks, Advantys STB I/O islands, ATV variable speed drives, etc) can in fact coexist on a single Ethernet TCP/IP network.
With regard to client-server type exchanges, between the PLC module and devices communicating in Modbus TCP protocol, the I/O Scanning mechanism is ideal. This can be used to define up to 128 periodic read or write exchanges via the configuration, on tables of word type variables, on these target devices. This I/O Scanning mechanism is a function available as standard with Quantum 140 NOE 771 01 and 140 NOE 771 11 Ethernet modules. This function also works in a Quantum Hot Standby architecture with Unity Pro.

As far as Ethernet network topology elements for connection between PLC modules and distributed devices are concerned, it is better to use switches rather than hubs. The topology adopted can be bus or ring type, copper wire or fiber optic, as appropriate.



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Functions

■ **Application program memory space**
All the memory space reserved for the application program can be managed by the Hot Standby system with Unity Pro. With an embedded RAM memory of 768 Kb, the RAM memory for the 140 CPU 671 60 processor, dedicated to Hot Standby applications, can be increased to 7.168 Mb by the addition of a PCMCIA format memory card.

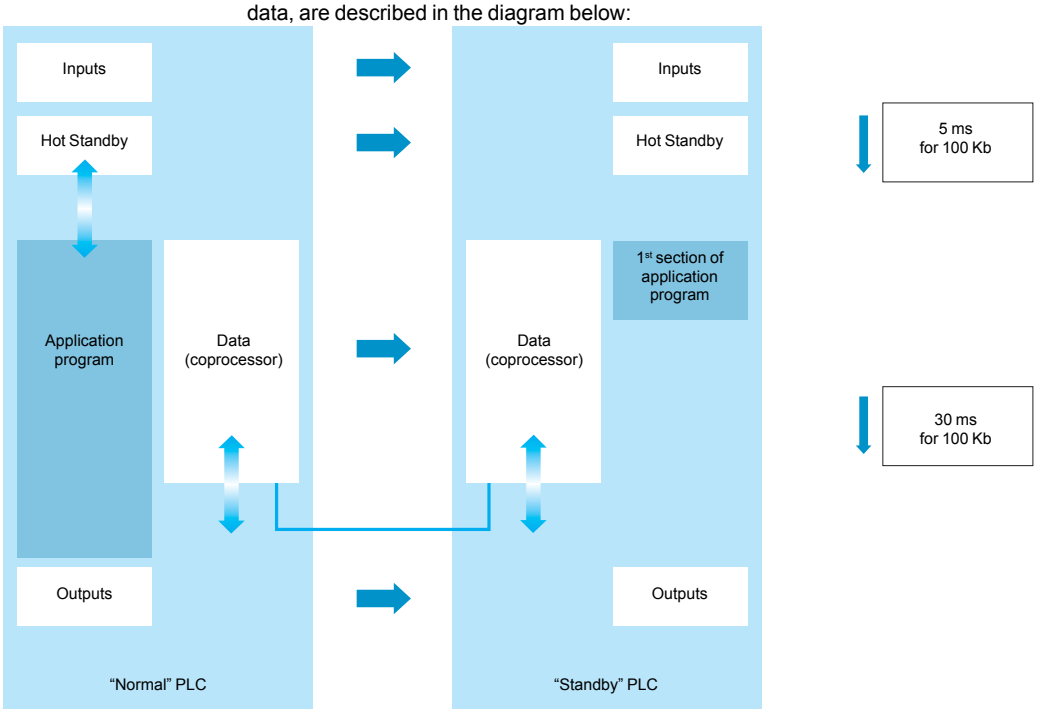
■ **Configuration**
Installation of the application program does not differ fundamentally from installing a simple PLC program. It essentially uses the information provided by a dedicated dialog box, entered at the configuration stage.

■ **Mini-terminal on front panel**
The 140 CPU 671 60 processor, like any Quantum CPU, comes in the form of a dual-slot module, and offers a mini-terminal at the top of the front panel. Equipped with an LCD screen and browse buttons, it has a special sub-menu for the standby system. It can be used for example to check the status of the PLC machine, to force it into connected or disconnected mode, with regard to the standby system.

■ **System registers**
Control of the standby system is managed by an internal register called the Command Register, carried by a system word. This Command Register accepts user requests, expressed via the configuration dialog box and/or via the mini-terminal on the front panel. This Command Register can be used in particular to disable acknowledgement of commands made from the mini-terminal.
Feedback on the status of this redundant system is given by a Status Register, which is also carried by a system word.

■ **Function blocks**
Standard function blocks are made available in the Unity Pro programming environment, making it possible to operate in read/write mode on the Command Register and in read mode on the Status Register, by identifying individually each of the bits carrying a particular function.

■ **Cyclic transfer of the application context**
At the start of each scan cycle, the content of the data memory in the “Normal” PLC is transferred to the “Standby” PLC via the fiber optic link, at the same time as the content of the tables that are images of the input and output states. The Hot Standby system is thus able to transfer all the 128 Kb made available to receive the located variables (RAM State) from the “Normal” PLC to the “Standby” PLC. As far as unlocated application variables are concerned, and also application data such as DFB instance data, for example, not less than 512 Kb can be transferred.
The principle of exchanges, as well as exchange times according to the volume of data, are described in the diagram below:



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Functions (continued)

■ **Monitoring of program discrepancies**
The majority of redundant PLC applications expect identical application programs on both CPUs. To this end, a comparison is made of the resident user program on both PLCs. It takes place immediately on power-up, and is repeated constantly while the redundancy system remains connected. By default, the “Standby” PLC will disconnect itself from the redundancy system as soon as a difference in program is detected. In order to maximize control/command system availability, including during interventions on the user program, it is however possible, via the configurator dialog box or via the command register, to authorize the continued connection of the redundancy system with applications whose program code and/or database are different.

■ **Ensuring parity of the content of the PLC memories**
On powering up the secondary PLC rack, parity of the content of the PLC memory in relation to that of the primary PLC rack is ensured automatically (Plug and Play) in several examples. This is particularly true when this secondary PLC is empty, or even when it contains a different configuration. At the end of the transfer, the redundancy system is connected, the primary PLC then takes the “Normal” role and the secondary the “Standby” role.
The user can also make a request for an upgrade via the mini-terminal, which can be accessed from the front panel of the “Normal” PLC, especially after a modification has been made to the application. This operation on the mini-terminal can be performed by a maintenance engineer, without needing to resort to a programming terminal. This function is also available via a Command Register bit.

■ **Upgrading operating systems**
A Command Register bit, positioned if necessary from the configuration dialog box of the Hot Standby system, is used for sequential upgrading of the operating systems of both PLC machines, while maintaining control of the process by the application program.

■ **Automatic exchange of communication port addresses**
When the redundancy system changes over, the respective addresses of the equivalent communication ports are exchanged automatically on the “Normal” and “Standby” PLCs. This exchange of addresses is unconditional for Ethernet and Modbus Plus ports. It occurs conditionally for the local Modbus port on the 140 CPU 671 60 processor. This function (automatic exchange of the communication port addresses) greatly simplifies the task of the developer on supervisory control systems (HMI, SCADA, etc). In effect, a data address thus characterizes an “operational” PLC (“Normal” or “Standby”) and not a physical PLC.

■ **Automatic exchange mechanisms during communication**
Irrespective of the I/O architectures used (RIO remote I/O or mixed I/O), the Hot Standby system automatically manages the exchange mechanisms between the I/O and the PLC performing the “Normal” function.

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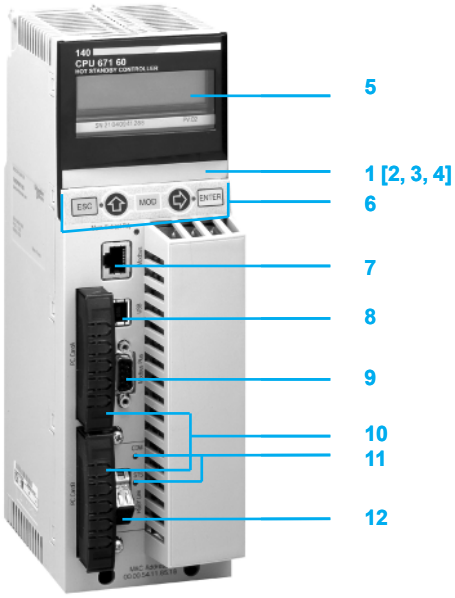

140 CPU 671 60

Description of the 140 CPU 671 60 processor

The 140 CPU 671 60 processor front panel comprises:

1 An LCD display cover, providing access to:
2 A key switch:
□ Unlocked: All system menu operations are able to be invoked and all changeable module parameters can be modified by the operator via the LCD and keypad, memory protection is off.
□ Locked: No system menu operations are able to be invoked and all changeable module parameters are read only, memory protection is on.
3 One battery backup slot
4 One reset button (Restart)
5 An LCD display (2 lines of 16 characters) with adjustable brightness and contrast controls
6 A 5-button keypad with 2 LEDs *(ESC, ENTER, MOD, ⇧, ⇨)*
7 An RJ45 connector for connecting to the Modbus bus
8 A type B female USB connector for connecting the programming PC terminal
9 One 9-pin female SUB-D connector for connecting to the Modbus Plus network
10 Two slots for PCMCIA memory extension cards
11 Two LEDs:
□ COM LED (green): activity on the Hot Standby primary or secondary drop
□ ERR LED (red): communication error between the Hot Standby primary and secondary drops
12 One MTRJ fiber optic connector for interconnecting the primary and secondary PLCs in the Hot Standby architecture

Mini operator dialog terminal

The mini operator dialog terminal, located on the front of the 140 CPU 671 60 processor, offers the user direct indication (RUN, STOP, No Conf) of the PLC status, without a programming terminal.
It can also be used to display, and if necessary to modify, a certain number of operating parameters, using the following browse buttons:
□ ESC
□ ENTER
□ MOD
□ ⇧
□ ⇨

Four main command functions are accessible from a menu/sub-menu tree structure:
□ Quantum PLC operating mode: **PLC Operations**
□ Communication port parameter settings: **Communications**
□ System information: **System Info**
□ LCD screen settings: **LCD Settings**

The **PLC Operations** menu is used to execute the following commands:
■ **Start PLC**
■ **Stop PLC**
■ **Init PLC**
It can also be used to go into the **Hot Standby** sub-menu offering commands specific to the redundancy system.

It is possible to display (**State** sub-menu) the connected/disconnected state (with regard to redundancy) of the PLC which the user is working on, and this sub-menu also offers the option of forcing (**Mode** sub-menu) this PLC in connected/disconnected state.

The other sub-menus are:
■ **Order:** delivers topological information on the current PLC
■ **Diag:** gives, if necessary, error information on the state of the standby system
■ **Transfer:** is used to transfer the content of the memory in the “Normal” PLC to that of the “Standby” PLC, for updating.

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Characteristics

Type of processor				140 CPU 671 60
Dimensions	Number of slots	Normal		2
		Standby		2
Microprocessor				Pentium 266 MHz
Memory backup	Battery	Type		3 V Lithium
		Service	**mAh**	1200
		Retention	**years**	10, with 0.5% loss of capacity per year
		Power off charge	**µA**	14 typical, 420 max.
Calendar clock	Drift		**s/day**	8.0 to 60°C
Maximum configuration	No. of racks with 2/3/4/6/10/16 slots	Main drop(s)		1 “Normal” rack/1 “Standby” rack
		Remote drops		31 I/O drops x 2 racks (primary rack + extension rack)
Inputs/Outputs	No. of discrete I/O points	Remote I/O drops		64 input words + 64 output words per I/O drop ie. 1024 inputs and 1024 outputs per I/O drop (max.) ie. 31,744 inputs and 31,744 outputs in total (max.)
	No. of analog I/O points	Remote I/O drops		64 input words + 64 output words per I/O drop ie. 64 inputs and 64 outputs per I/O drop (max.) ie. 1984 inputs and 1984 outputs (max.)
	Special purpose modules			Intrinsic safety I/O, high-speed counting, ASCII, accurate time stamping
Communications	No. of optional modules	Ethernet, Modbus Plus		6
	Max. no. of ports	Modbus		1 port integrated in the Quantum CPU (RS 232/485)
		As-Interface		4 on remote rack (drop)
		Modbus Plus		1 port integrated in the Quantum CPU 6 ports max. on additional modules
		Ethernet		1 x 100 Mbps port integrated in the Quantum CPU used exclusively for the Normal/Standby link 6 x 10/100 Mbps ports max. on additional modules
		USB		1 programming port only
Functions	Mini operator dialog terminal			Integrated on the front panel
	Redundancy			Power supplies (option), RIO wiring (option), Modbus Plus (option)
	Process control			Yes
	Hot Standby			Redundant coprocessor integrated in the Quantum CPU Normal/Standby link on integrated100 Mbps fiber optic port
Memory	Configuration data - max.		**Kb**	128
	Program		**Kb**	768 possible extension to 7168 with PCMCIA card (upper slot)
	Unlocated variables + internal data		**Kb**	512 max.
	Located variables (max.) *(RAM State)*		**Kb**	128
	Located internal bits (%Mi)		**bits**	64 K all I/O combinations
	File storage		**Mb**	Up to 8 Mb on PCMCIA card (lower slot)
Application structure	Master task (FAST)			1 cyclic/periodic
	Fast task (FAST) *(2)*			1 periodic *(4)*
	Auxiliary task *(2)*			4 *(4)*
	Software interrupt task *(3)*			32 *(4)*
Execution time for one instruction *(1)*	Boolean		**µs**	0.0525…0.075
	On words or fixed point arithmetic		**µs**	0.0450…0.060
	On floating point		**µs**	0.400…0.500
No. of Kinstructions executed per ms *(1)*	100% Boolean		**Kinst/ ms**	10.28
	65% Boolean and 35% numerical		**Kinst/ ms**	10.07
System overhead	Master task (FAST)		**ms**	1
	Fast task (FAST)		**ms**	0.2

(1) Variable values according to the type of instruction.
(2) It is recommended that only a MAST task is used for Hot Standby applications with Unity Pro. The use of FAST and AUX tasks is not however totally prohibited. Nonetheless, if you wish to do so, an exhaustive detailed analysis of the possible effects of their use should be undertaken.
(3) Resorting to a multi-task organization may involve modifications of the image data tables within a single scan, even during transfer of data from Normal to Standby; as a matter of principle, these modifications take place asynchronously in relation to the PLC scan cycle. For these reasons, it is therefore recommended that only a MAST task is used for Hot Standby applications with Unity Pro.
(4) Use not recommended with the Hot Standby system.

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References

Hot Standby CPU with Unity Pro

Hot Standby CPU		Memory (max.)			Communication ports	Reference	Weight kg
Clock speed	**Coprocessor**	**RAM**	**Program** (with located variables)	**Program with PCMCIA card.**			
266 MHz	Yes, integrated Ethernet TCP/IP, use reserved for Hot Standby	2 Mb	896 Kb	7168 Kb	1 Modbus *(1)* 1 Modbus Plus 1 USB 1 Ethernet 100 Mbps port, used as Hot Standby port	**140 CPU 671 60**	–

Associated modules

Description	Topology	Reference	Weight kg
RIO central control unit modules	Simple cable	**140 CRP 931 00**	–
	Redundant cable	**140 CRP 932 00**	–

Accessories

Description	Use/composition	Length	Reference	Weight kg
Splitter	Tee for joining sections of coaxial cable coming from 2 central control unit modules (140 CRP 93● 00). Constitutes the start of the RIO I/O backbone.	–	**MA 0186 100**	–
Line impedance for coaxial cable RG-6/RG-11	Impedance for RIO coaxial cable. Used to maintain a suitable RIO line on disconnection of the cable coming from the central control unit (140 CRP 93● 00). Connection at both ends on female connector.	–	**990 XCA 656 09**	–
Earthing terminal for coaxial cable RG-6/RG-11	Earthing terminal for RIO coaxial cable. Used to maintain earthing of the RIO line on disconnection of the cable coming from the central control unit (140 CRP 93● 00). Connection at both ends on female connector.	–	**60 0545 000**	–
Jumpers for fiber optic cable	62.5/125 multimode fiber optic cable, equipped with MT-RJ connectors. Designed to connect the100 Mbps Ethernet ports of 140 CPU 671 60 processors (“Normal” and “Standby”), in order to make up the data update channel.	3 m	**490 NOR 000 03**	–
		5 m	**490 NOR 000 05**	–
		15 m	**490 NOR 000 15**	–

(1) Modbus RS 232/RS 485 port