VME-Based Programmable Automation Controller
PACSystems™ RX7i

Guide Form Specification

GFT-516

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imagination at work

1 General

1.1 Project Objectives

This specification describes the functional requirements, design features, hardware, software, system performance, services, and documentation required for a control in a scalable discrete or hybrid control system.

The control system shall perform as a minimum the following functions as defined in the specific sections of this document:

- Control system must comply with the requirements for an Programmable Automation Control.
- System must be open architecture with the control functions being modular and scalable
- Optional redundancy for servers, controllers, networks, and I/O
- High speed , deterministic, peer to peer communications between control systems
- Ability to communicate with 3rd party devices and controllers with fieldbus connections
- Integrated environment for all applications (discrete, process, motion, MMI) development, configuration, commissioning, monitoring, and maintaining with one database
- Complete management system for all access levels to control application for necessary security requirements
- Either integrated in the control system or through standards based connections (Ethernet, OPC), interface and share database with high level HMI/SCADA system with Historian, Trending, and additional functionality
- Integrated Alarms and Events
- Web connectivity for interface to control for monitoring and maintaining
- Compliant with safety and environmental regulations

1.2 Programmable Automation Control Definition

The requirements for a Programmable Automation Control (PAC) are:

Multi-domain functionality, including logic, motion, and HMI for discrete and process control on a single platform

Will allow users & OEMs to deploy multiple control applications on a single platform

Common development platform for the design and integration of multi-domain automated systems

Will facilitate open, modular control architectures that enable highly distributed automated factory environments

Employ de-facto standards for network interfaces, languages, etc., allowing data exchanges as part of networked multi-vendor systems

1.3 Other Definitions

- PACSystems™: GE Fanuc's line of Programmable Automation Controllers. PACSystems takes PAC one step farther with a portable engine built on standards. This allows the same application to be run on multiple platforms.
- Ethernet: A very high performance local area network standard providing the two lower levels of the ISO/OSI seven layer reference model, the physical layer and the data link layer.
- TCP/IP: a protocol widely used across Ethernet networks for connecting computers and programmable controllers.
- Web Browser: A client application that provides a user interface via the World Wide Web. Netscape and Microsoft Internet Explorer are two popular examples.
- Communications Protocol: A formal set of conventions governing the control of Inputs and Outputs between the two communicating processes.
- Network: An interconnected group of nodes, a series of devices, nodes or stations connected by communications channels.
- CMX/RMX: Control Memory Xchange/Redundancy Memory Xchange – a new technology that communicates very large amounts of data at deterministic sub microsecond times.
- Operating System: A program that controls the entire overall operation of the system hardware / software. PACSystems use standard operating systems to allow program portability and application flexibility.

2 System Architecture

The system shall be an open micro-processor, VME based system with a standard operating system and a PAC application execution engine. An expansion bus must be available for connecting to standard communications networks. Built in Serial and Ethernet ports shall also be available.

- The system shall have the ability to add 3rd party VME modules in the rack.
- The system will be shipped ready for use. The ports communication settings will be set using the operating system.

2.1 Operating System

The operating system shall be VXWorks or Microsoft CE. This is a full 32-bit operating system that is standard

2.2 Development and Run Time system

The system shall include a run time engine for execution of automation applications.

The development system is a tool, which fully integrates control, motion, and visualization. This tool shall be a Windows base environment. The development environment must share the same set of tools, providing a consistent user interface throughout the development process. The system shall provide drag-and-drop capabilities between tools and editors.

The development system shall be scalable across a full range of control, motion, OI, and HMI applications.

2.3 Networking

2.3.1 Ethernet

The system shall be capable of supporting the following Ethernet features:

- Data exchange using Ethernet Global Data (EGD)
- TCP/IP communication services using SRTP
- Full PAC programming and configuration services
- Comprehensive station management and diagnostic tools
- Extends the connectivity of a control with IEEE 802.3 CSMA/CD 10Mbps and 100Mbps Ethernet LAN ports.
- The Ethernet Interface contains two full-duplex 10BaseT/100BaseT/TX (RJ-45 Connector) ports with an internal network switch providing auto-negotiated network speed, duplex mode, and crossover detection.
- Use of BaseT permits direct connection to BaseT (twisted pair) network hub or repeater without an external transceiver.
- Firmware is pre-loaded for easy installation and is maintained indefinitely; firmware is easily upgraded in-system through the CPU serial port using a simple loader.
- IEEE 802.3 Media – The Ethernet interface can operate directly on 10BaseT/100BaseTX media via its network ports. These media are described below.

10BaseT: 10BaseT uses a twisted pair cable of up to 100 meters in length between each node and a hub or repeater. Typical hubs or repeaters support 6 to 12 nodes connected in a star wiring topology.

100BaseTX: 100BaseTX also uses a cable of up to 100 meters in length between each node and a hub or repeater. The cable should be data grade Category 5 unshielded twisted pair (UTP) or shielded twisted pair (STP) cable. Two pairs of wire are used, one for transmission, and the other for collision detection and receive. Typical hubs or repeaters support 6 to 12 nodes connected in a star wiring topology.

2.3.2 Control Memory Xchange

The system must support integrated Control Memory Xchange communications from Control to Control and to other 3rd party devices.

Control Memory Xchange has the following features:

- 2.12 gigabaud
- Transfer rates of 43 Mbyte/s to 174 Mbyte/s
- 256 nodes in a ring
- Multi-Mode fiber up to 300m
- Data insertion technique
- Easy to use - Just Memory, Read it & Write it
- Writes are stored in local RAM & immediately broadcast to other nodes
- Each network node has a local copy of all the data
- Reads access the local data copy
- Supports16mb initially of on board memory
- Real-time deterministic data delivery
- Data can be shared among systems regardless of processor type, operating system, bus structure
- Addition modules available for:

3rd party standard VME systems

PCI based systems

Systems requiring beyond 300m up to 10Km

2.3.3 Other Communication Options

2.3.3.1 The system shall be capable of expansion to support Fieldbus communication configurations:

GE Fanuc Series 90-70 Parallel I/O

Ethernet

GE Genius

DeviceNet Master

PROFIBUS Master

2.3.3.2 The system shall be capable of supporting the following Serial communication configurations:

- COM1 – General purpose bi-direction serial data channel supporting EIA232C and EIA485 electrical standards
- COM2 - General purpose bi-direction serial data channel supporting EIA232C electrical standards

2.3.3.3 The system shall be capable of supporting the following serial network Protocols:

- Modbus RTU Slave
- GE Fanuc SNP, SNP-X
- Modbus RTU

2.4 Performance

Controller execution lowest period	1ms
Redundancy supported with low overhead	Yes
Remote I/O with variety of networks	Yes
Peer to Peer preferred update rate (50,000 tags)	1ms
Typical input rate	25ms
High density analog input rate	100ms
High speed digital input rate	1ms
RTD/Thermocouple	50ms

3 Programming Environment

3.1 System Architecture

The integrated automation software development environment shall have the ability to implement the following:

- A full-featured MMI application
- A full featured Control application
- A full featured Motion application

3.1.1 Operating System

The operating system shall be Microsoft Windows NT v4.0, Windows 2000 or Windows XP Professional.

3.1.2 Hardware Requirements

The system shall be capable of operating on a minimum configuration of:

- 500 MHz Pentium-based workstation
- 128 MB RAM
- 750 MB hard disk space
- TCP/IP Network protocol-based workstation

Optionally, the system shall also be capable of supporting:

- Additional RAM memory
- Larger hard drive
- Support of multiple port serial add-on boards
- High-speed PAC communication cards
- Touch-screen monitor

3.2 Licensing

3.2.1 It shall be possible to license all components in the integrated development environment with one serial number and through one authorization event, whether that be with a hardware key or software authorization.

3.2.2 The licensing mechanism shall support single user licenses as well as site licenses. The site licenses must not require any web or telephone authorization process.

3.3 Documentation

3.3.1 The system shall provide complete user documentation, including examples of how to operate the various modules within the system. The documentation must be in electronic format, HTML based with the ability to search for topics by keyword or search for specific text.

3.3.2 The online help system in the product needs to be context sensitive such that immediate help is available for the selected functionality.

3.3.3 An on-line "help" facility, based upon Windows standard Hypertext, shall provide useful, context-sensitive information on the operation of the package. This help facility shall be capable of being invoked on-line through a point-and-click operation. The "help" facility must also support the ability to perform full text word search, copy and pasting into another applications, print, and use of system fonts and colors.

3.3.4 Product Documentation must be available on the vendor's web site for users to download.

3.4 Sample System

The vendor shall provide a set of samples to assists a user in using the software for the first time. Samples shall be available for OI/MMI, Control, and Motion and shall demonstrate most of the features available in the software.

3.5 Common Components

3.5.1 Single Database

3.5.1.1 The integrated development environment must support a centralized data manager that will support all of the variables used in a project, so as to avoid data entry duplication. Automatic import/export is not acceptable.

3.5.1.2 If a variable is renamed in one location, all other references to that variable must automatically be updated to reflect the new name of the variable.

3.5.2 Object Re-use

3.5.2.1 The development system shall provide a repository of preconfigured object templates, which can be dragged-and-dropped into an automation application. These objects can be as simple as a single ladder logic instruction, or as complex as a robotic arm with fully configured ladder logic and HMI animation.

3.5.2.2 The object repository shall be pre-populated with logic instructions, scripting commands, and graphical objects and can be extended by the user by selecting the object in logic or on a graphics panel and dragging it into the repository.

3.5.2.3 The object repository must allow objects to be shared across applications and support a mechanism to distribute the objects to various stations

3.5.2.4 If an object in the repository is modified, all applications that made reference to that object must automatically be updated the next time the application is used.

3.5.3 User Interface

3.5.3.1 All editors within the development environment must share a single workspace and a common set of tools.

3.5.3.2 The look-and-feel of all editors within the environment must share a similar design philosophy so as to ensure a standardized user interface across the application.

3.5.4 Project based Cross-referencing

3.5.4.1 The development environment must provide a list of all locations in the project, whether they are in Control, HMI, or Motion, where a particular variable is being used.

3.5.4.2 The environment must maintain this list automatically for all variables in the project so as to eliminate the need to initiate individual searches through the application when this information is required.

3.5.5 Transparent Data Exchange

3.5.5.1 The software must provide automatic routing of data between all applications in the project, whether they reside on the same hardware (computer, PLC, etc.) or across a network.

4 Manufacturer's Qualifications

4.1 Design and Manufacture

The programmable automation controller and all of the corresponding components within the family of controller products shall be offered by a company who regularly manufactures and services this type of equipment. It shall have attained ISO9001 registration.

4.1.1 Standards

All products shall be designed, manufactured, and tested in accordance with recognized industrial standards.

AGENCY APPROVALS		
Type	Standard	Comments
Quality Assurance in Design/Development, Production, Installation & Service	ISO9000	Certification by Underwriters Laboratories and British Standards Institute
Industrial Control Equipment (Safety)	UL508	Certification by Underwriters Laboratories
Process Control Equipment (Safety)	CSA22.2, 142-M1987 or C-UL	Certification by Canadian Standards Association or Underwriters Laboratories
Hazardous Locations (Safety) Class I, Div II, A, B, C, D	UL1604	Certification by Underwriters Laboratory
European EMC Directive	CE Mark	Certification by Competent Body for EMC Directive
ENVIROMENTAL		
Type	Standard	Conditions
Vibration	IEC68-2-6, JISC0911	1G @ 40-150Hz, 0.012in peak to peak @ 10-40Hz
Shock	IEC68-2-27 JISC0912	15G, 11ms
Operating Temperature		0°C to 55°C inlet standard without fans for lower models and with fans for higher
Storage Temperature		-40°C to +85°C
Humidity		5% to 95%, non-condensing
Enclosure Protection	IEC529	Steel cabinet per IP54: protection for dust & splashing
EMC EMISSIONS		
Type	Standard	Conditions
Radiated, Conducted	FCC CISPR11; EN55011	Part 15, section J, Class A
EMC IMMUNITY		
Type	Standard	Conditions
Electrostatic Discharge	IEC801-2	8KV Air Discharge. 4Kv Contact Discharge
Radiated RF	IEC801-3	10Vrms/m, 80Mhz to 1000Mhz, modulated
Fast Transient Burst	IEC801-4	2KV:power supplies, 1KV: I/O, communications
Surge Withstand	ANSI/IEEE C37.90a IEC255-4	2.5KV [cmn, diff mode]; power supplies, I/O [12V- 240V]
Conducted RF	IEC801-6	10V, 150Khz to 80Mhz injected for communication cables > 30meters
ISOLATION		
Type	Standard	Conditions
Dielectric Withstand	UL508, UL840, IEC664	1.5KV for modules rated from 30V to 250V
POWER SUPPLIES	IEC1000-4-11	During operation: Dips to 30% and 100%, Variation for AC ±10%, DC ±20%

4.1.1.1 The manufacturer shall have a fully operational quality assurance and quality control program in place and shall comply with ISO9001 standards for "Quality Systems- Model for Quality Assurance in Design/Development, Production, Installation, and Servicing".

4.1.1.2 Complete product documentation describing installation, operation, programming and simple field maintenance shall be available in paper format and on CD-ROM.SUPPORT.

4.2 Installation Services

4.2.1.1 The vendor shall have the ability to provide qualified consulting and installation services. These services need to be provided either by the vendor or via certified partners. Services include:

- Site Assessment
- Consultation
- Implementation
- Assistance and turnkey
- Validation services

4.2.1.2 Vendor needs to be able to provide service and support the installations locally and worldwide.

4.3 Support

The manufacturer or its authorized representative shall provide complete technical support for all of the products. This shall include headquarters or local training, regional application centers, and local or headquarters technical assistance. A toll-free (800) number hot-line shall be available for technical support.

4.4 Hardware Warranty

Product shall have a warranty period of at least 1 year from the date of purchase.

4.5 Software Warranty

4.5.1.1 Vendor shall provide the option to purchase support contract. This contract is to include:

- Telephone and Email support Mon-Fri 8:00AM to 8:00PM EST
- 24x7 Emergency Support
- Software Upgrades
- 24x7 Access to web based technical and support information

4.5.1.2 The vendor shall have a location on their web site where users can download software improvements, bug fixes, add-ons, components and so forth.

4.5.1.3 The vendor shall provide an easy mechanism for upgrading and installing software improvements and for allowing a user to quickly ascertain what improvements have been installed.

4.5.1.4 The manufacturer or it's authorized representative shall provide complete technical support for all of the products. This shall include headquarters or local training, regional application centers, local or headquarters technical assistance and a "1-800" phone line.

5 Mechanical

The system shall consist of rigid components designed specifically for industrial environments. A complete system shall consist of one or more racks containing I/O modules, interconnected by power and data cables.

5.1 Packaging

All components shall be housed in structurally secure racks which can mounted local or remote.

5.1.1.1 The controller CPU shall be modular. When mounted on the system rack, the CPU shall not occupy more than one available slot.

5.1.1.2 The I/O system shall be modular. Each module shall consist of one or more printed circuit boards attached to a durable plastic face assembly. When mounted on the system rack, most I/O modules shall not occupy more than one available slot.

5.1.1.3 There shall be a main rack with with slots that are half as wide, for a total of 17 half-width slots. This rack will accommodate a wide range of modules that meet the Versa Modular Eurocard (VME) standard.

5.1.1.4 There shall be two sizes of expansion racks available. One shall hold up to 8 I/O modules and the other shall hold up to 4 I/O modules. In addition, the rack shall also hold a power supply and local interface module. A second version of the nine slot rack shall be available with slots that are half as wide, for a total of 17 half-width slots. This rack will accommodate a wide range of modules that meet the Versa Modular Eurocard (VME) standard.

5.1.1.5 Racks shall be available for installation directly in a standard 19" rack or alternatively, flush or surface mounted.

5.1.1.6 Each I/O module shall be mechanically keyed to prevent the accidental interchange of one I/O module type for another.

5.1.1.7 Remote I/O shall be mounted on din rail.

5.2 Durability

All cables furnished by the manufacturer shall be constructed so as to withstand, without damage, all normal use and handling.

5.3 Parts Interchangability

In order to minimize spare parts stocking requirements, the controller family shall have a high degree of interchangeability.

5.3.1.1 The system shall incorporate a modular design using plug-in assemblies.

5.3.1.2 Wherever possible, all assemblies and sub-assemblies performing similar functions shall be interchangeable.

5.3.1.3 The system design shall accommodate the replacement of assemblies without having to disconnect field wiring. Universal removable terminal strips shall be available to connect field wiring to the individual circuit board assemblies.

5.3.1.4 Universal module faceplates with color-coded, slip-in labels shall be available. The outside label features both color-coding for module specification and labeling space for I/O point identification. The inside label shall feature a detailed wiring diagram complete with the module catalog number and description.

5.3.1.5 All major assemblies and sub-assemblies, circuit boards, and devices shall be identified using permanent labels or markings, each of which indicates the manufacturer's catalog number and a product manufacturing date code.

5.4 VME Compatibility

The PAC system backplane shall accept the integration of 3rd party VME modules with the particular characteristics of the Industrialized VME bus specification C.1.

6 Power Supply

A power supply for the CPU and Expansion racks shall be available for the following service conditions:

Nominal	Min. - Max.	Frequency
120/240 VAC	90 - 264 VAC	47-63 Hz.
125 VDC (3rd qtr 2004)	100 - 150 VDC	N/A
24 VDC (3rd qtr 2004)	18 - 32 VDC	N/A

6.1 Installation

6.1.1 Main Rack power supplies shall be available with the following power output (max at all outputs):

100W	350W
5 VDC, 20A	5 VDC, 60A
+12VDC, 2A	+12VDC, 12A
-12VDC, 1A	-12VDC, 4A

6.1.2 Expansion rack power supplies shall be available with the following power output (max at all outputs):

55W	100W
5 VDC	5 VDC, +/-12VDC

6.1.3 The power supply shall be modular in form with slide-in rack mount construction using PICMG 2.11 standard connector.

6.1.4 The power supply shall not consume an available I/O slot.

6.1.5 Electronic short circuit overcurrent protection

6.1.6 Electronic overvoltage and overtemperature fault protection

6.1.7 Power Factor correction for AC operation

7 Central Processing Unit (CPU)

Provides the following features:

- Supports up to 10 Mbytes of battery-backed user memory.
- Provides access to bulk memory via reference table %W, which is configurable up to 4Mbytes.
- Contains 10Mbyte of non-volatile flash user memory.
- Configurable data and program memory.
- Supports auto-located Symbolic Variables that can use any amount of user memory.
- Larger reference table sizes include 32Kbits for discrete %I and %Q and up to 32Kwords each for analog %AI and %AQ.
- Supports Series 90-70 discrete and analog I/O, Genius Bus Controller and High Speed Counter.
- Supports high-density Series 90-70 I/O modules.
- Supports PAC data monitoring over the web. Allows a combined total of up to 16 web server and FTP connections.
- Supports up to 512 program blocks. Maximum size for a block is 128KB.
- Test Edit mode allows you to easily test modifications to a running program.
- Bit-in-word referencing allows you to specify individual bits in a WORD reference in retentive memory as inputs and outputs of Boolean expressions, function blocks, and calls that accept bit parameters.
- Battery-backed calendar clock.
- In-system upgradeable firmware.
- Three serial ports: an RS-485 isolated serial port, an RS-232 isolated serial port, and an RS-232 isolated Ethernet station manager serial port.
- The embedded Ethernet interface provides:

Data exchange using Ethernet Global Data (EGD)

TCP/IP communication services using SRTP

Full PAC programming and configuration services

Comprehensive station management and diagnostic tools

Two full-duplex 10BaseT/100BaseT/TX (RJ-45 Connector) ports with an internal network switch providing auto-negotiated network speed, duplex mode, and crossover detection.

7.1 Instruction Set

The CPU or coprocessor shall be capable of solving an application program whose source format shall be relay ladder diagram, "C", State Logic or Sequential Function Chart (SFC). The language shall support arithmetic, logical, and data processing functions.

7.1.1 It shall be possible to divide user logic into multiple program blocks (structured programming).

7.1.2 Program blocks shall be called from the Main block or subordinate blocks based on conditional logic. Blocks will not have to be executed every scan. Blocks shall support symbolic memory, functional data types, global and local data, multiple blocks and variable declaration. It shall be possible to reuse blocks using a file import/export function.

7.1.3 Four different functions shall be available to lock and unlock program blocks:

- viewlock (the block logic cannot be viewed)
- editlock (the block cannot be changed)
- permviewlock (viewlock that cannot be removed)
- permeditlock (editlock that cannot be removed)

7.1.4 It shall be possible to write program blocks in other programming languages such as "C".

7.1.5 It shall be possible to perform a single sweep of logic for debugging purposes.

7.1.6 There shall be backplane driver support for third party integration.

7.2 Relay Logic

7.2.1 As a minimum, the basic relay ladder operations shall consist of:

normally open contact	jump
normally closed contact	timer- on delay
latch contact	timer- off delay
oneshot contact- pos./neg.	timer- elapsed
oneshot coil- pos./neg.	timed interrupt
set coil	counter- up
reset coil	counter- down
negated coil	fault contact
retentive coil	no fault contact
negated retentive coil	high alarm contact
continuation coil (multi-line rung	low alarm contact
continuation contact	transitional contact
for-next (counter & jump loop)	data initialization

7.2.2 Contacts may be referenced any number of times within the application program. Multiple output references to coils (normal, latch, one-shot) shall normally not be allowed, but the programming workstation shall have the ability to disable and re-enable the coil checking operation. Three checking modes shall be available:

Single	single use only
Warn Multiple	multiple use allowed with warning issued
Multiple	multiple use allowed

7.2.3 The use of dummy reference addresses shall be possible. These variables will act as place holders for actual references.

7.3 Timers and Counters

There shall be up to 5000 programmable timers and counters. The only limitation shall be the amount of program and register memory available. The time/count limit shall be either a programmed constant having a range of values 0 to 32767 or shall be programmable via a register value. In this case the range of values shall be 0 to 32767. The accumulated count or current time shall be accessible directly from any location within the application program via a register reference. Each timer shall have a selectable time base of 1.0, 0.1 or 0.01 seconds.

7.4 Arithmetic

The arithmetic operations shall use simple data types in 16 bit or 32 bit integer representation. Data types shall include signed integer, unsigned integer and signed double precision integer. The operands of an arithmetic function may be register values or programmed constants. In general, power flow from the function shall indicate the status of the operation: success or error.

7.4.1 Single Precision

The single precision arithmetic functions shall use a 16 bit word length. Unsigned operations shall be in pure binary and signed operations shall be in 2's complement format.

add- signed/unsigned	divide- signed/unsigned
subtract- signed/unsigned	modulo- signed/unsigned
multiply- signed/unsigned	square root
mixed type multiply	

7.4.2 Double Precision

The double precision arithmetic functions shall use a 32 bit word length in 2's complement format.

signed add	signed divide
signed subtract	signed modulo
signed multiply	square root

7.4.3 Relational

The relational functions are available to both single and double precision data types.

3 way compare	less than
equal	greater than
greater than or equal	not equal
less than or equal	range

7.4.4 Floating Point

Floating point math shall including the following functions:

add	inverse sine
subtract	inverse cosine
multiply	inverse tangent
divide	logarithm (base 10)
modulo	natural logarithm
square root	exponential (e to the power x)
absolute value	exponential (x to the power y)
sine	radian to degree conversion
cosine	degree to radian conversion
tangent	

7.5 Data Operations

Data operations shall be performed using a combination of TABLE, MOVE, CONVERSION, BIT, and BIT MATRIX operators. The ability to import blocks of data from external sources such as spreadsheets shall be included.

7.5.1 Table

Table operations shall consist of moving data into or out of tables, and sorting tables by value. Table elements shall be based on a 16 bit word and table length may be up to 256 words.

Valid data types include word, double word, signed integer, unsigned integer and double precision integer. In general, power flow from the function shall indicate the status of the operation.

table read	LIFO read
table write	LIFO write
array move	FIFO read

7.5.2 Move

The set of MOVE operations shall include the ability to word (16 bit) or multi-word data. Also, programmed constants shall be capable of being moved into registers under control of ladder logic.

move	swap-bytes/words
constant block move	VME read
memory block clear	VME write
shift register	VME read/modify/write
bit sequencer	VME test and set
communications request	VME configuration read
data initialization	VME configuration write

7.5.3 Conversion

The following data type conversion functions shall be available:

convert to integer

convert to unsigned integer

convert to double precision integer

convert to 4-digit BCD

convert to 8-digit BCD

convert to floating point

7.5.4 Bit Operations

A variety of bit operators shall be available which are capable of operating upon word (16 bit) or multi-word operands. Power flow from the function shall indicate the state of the most significant shifted bit. The following bit operations shall be available:

- shift "n" bits left/right
- rotate "n" bits left/right
- bit set/clear/sense
- masked compare

A bit sequencer function shall be available, which is used to perform a bit sequence shift through an array.

7.5.5 Bit Matrix Operations

Bits within an "n" word array shall be capable of being operated upon as an entity. The following operations shall be available:

and	or
not	exclusive or

7.5.6 Control

The following operations shall be available to limit program execution and alter the way the CPU executes the application program:

7.5.6.1 Suspend all I/O service

7.5.6.2 Update a specified range of I/O. This function may executed anywhere within the application. It may be included within the application program multiple times, within the limits of the CPU scan time constraint. Optionally, a copy of the scanned input may be placed in internal memory, rather than the input table.

7.5.6.3 Call a specified user program block.

7.5.6.4 Cause program execution to jump, bidirectionally, to a specified location in the logic.

7.5.6.5 The Master-Control-Relay function must execute so that all relay contacts that are attached to the power rail, between the Master-Control-Relay and the Master-Control_Relay-End function are forced off when the Master-Control-Relay function does not power flow.

7.5.6.6 Provide a service request function to request special PAC services:

- Change/Read Constant Sweep Timer.
- Read window values.
- Change Programmer Communications Window state and values.
- Change System Communications Window state and values.
- Change Background Task Window state and values.
- Change/Read checksum task state and length.
- Change/Read Time of Day Clock state and values.
- Reset Watchdog Timer.
- Read Real Time Clock.
- Read Sweep Time.
- Read PAC run state.
- Stop PAC.
- Read/Clear fault tables.
- Read I/O override status.
- Read Programmer/Controller ID.
- Mask/Unmask I/O Interrupt.
- Define user faults

7.5.6.7 Communicate with intelligent option modules using a Communications Request function block.

7.5.6.8 Provide a built-in PID function block with the capability of using either the ISA algorithm or the Independent Term algorithm. Additionally, the programming software must make provisions for loop tuning and include a graphic user interface for monitoring the PID set point and current value.

7.5.6.9 Indirect addressing of user references (supported by function blocks).

7.5.6.10 Interrupt based on user specified intervals (timed interrupts). There shall be four time bases:

0.001 sec., 0.01 sec., 0.1 sec., 1.0 sec.; and four execution offsets:

0.001 sec., 0.01 sec., 0.1 sec., 1.0 sec.

7.5.6.11 Control the programmer window, control the communications window and operate in the constant scan mode.

7.5.6.12 Support For-Next looping allowing rung logic to be repeated a specific number of times.

7.6 High Level Diagnostics

The CPU shall support high level diagnostics in conjunction with the intelligent, distributed and each type I/O system.

7.6.1 Faults shall be handled by a built-in software utility which time-stamps, describes and logs I/O and system faults.

7.6.2 Fault information shall be respectively stored in either the I/O or PAC dedicated fault tables, which may be examined from the programming workstation operator interface or other host device. Detailed information shall be available including an error code, default action, a description of the error and appropriate corrective action.

8 I/O System

There shall be two I/O systems available: one is a centralized, rack oriented design; the other is a highly distributed, intelligent I/O design. Both I/O systems may be present and operating concurrently within a single CPU system.

8.1.1 The I/O system shall have the following addressing capabilities defined by the CPU model used:

CPU Model	Medium	Large	Very Large
Discrete I/O	512	2K	12K
Analog I/O	8K	8K	8K

8.1.2 I/O addresses shall be software configurable. No dip switches or jumpers shall be required.

8.2 Rack Mounted I/O

I/O modules shall be installed in metal and plastic rack assemblies which are interconnected by I/O cables. There shall be two mechanisms by which racks communicate with the programmable controller CPU. One shall utilize a high speed, fully parallel interface. The other scheme shall utilize a high speed serial interface.

8.2.1 Parallel I/O Interface

8.2.1.1 The high speed parallel interface shall be capable of extending up to 50 cable feet maximum from the CPU using the same ground potential.

8.2.1.2 Parallel I/O communications shall include a parity check and shall monitor all connected bases for various types of faults.

8.2.1.3 System I/O status shall be displayed on LEDs which are present at each module. Also, the status and faults shall be available to an optionally connected programming workstation.

8.2.2 Serial I/O Interface

The high speed serial interface shall be capable of servicing either rack mounted or block I/O up to 7,500 cable feet beyond the rack of origin. The system shall be able to support multiple remote I/O interfaces.

8.2.2.1 The I/O interfaces shall be interconnected using a twisted, shielded pair cable, as recommended by the manufacturer.

8.2.2.2 The data transmission rate shall be adjustable up to 153.6 Kbaud. The communications shall use a high speed token passing network.

8.2.2.3 The Serial I/O interface shall be capable of supporting both discrete I/O block type I/O as well as modular rack type I/O in a distributed function on the same network.

8.2.3 Discrete I/O Family

In general, I/O modules shall be designed for 1500 volt isolation between the field wiring and the system backplane and for 500 volt isolation between fused groups. As a minimum, the following I/O selections shall be available:

Input Modules	# CKTS
12 Vac	32
24 Vac	32
48 Vac	32
120 Vac	16
120 Vac	32
120 Vac, Isolated	16
240 Vac, Isolated	16
12 Vdc	32 (+/- Logic)
24 Vdc	32 (+/- Logic)
	32 (+ Logic)
48 Vdc	32 (+/- Logic)
TTL	32 (- Logic)
125 Vdc	16

Output Modules	# CKTS
120 Vac	32 (0.5 Amp)
	16 (2.0 Amp)
120/240 Vac, Isolated	12 (2.0 Amp)
12 Vdc	32 (0.5 Amp, + Logic)
5/48 Vdc	32 (0.5 Amp, - Logic)
24/48 Vdc	16 (2.0 Amp, + Logic)
	32 (0.5 Amp, + Logic)
Signal Relay	16 (2.0 Amp : 240 Vac and 24 Vdc)
	16 (0.2 Amp : 48/125 Vdc)

8.2.3.1 The first input of DC input modules shall be software configurable as a CPU interrupt.

8.2.3.2 The filter time constant of DC input modules (TTL excluded) shall be selectable to either 1 or 10 msec.

8.2.3.3 The High Speed Counter shall accept up to four independent counters and four independent outputs. The High Speed Counter will have the following counter functions:

- Type A
- Type B
- Type C
- Type D
- Type E

8.2.4 Analog I/O Family

As a minimum, the following I/O selections shall be available:

Description	Input Module (# CKTS)	Output Module (# CKTS)
High Level		
0 to +10 Vdc	8	4
-10 to +10 Vdc	8	4
0 to +5 Vdc	8	4
-5 to +5 Vdc	8	4
4 to 20 mA	8	4
Expansion		
-10 to +10 Vdc	16	
+4 to +20 mA	16	

8.2.4.1 The modules shall have 1500 volt isolation, field wiring to system backplane.

8.2.4.2 All analog I/O shall be software configurable for range, fault reporting, alarm limits, and engineering scaling units on a channel-by-channel basis (except expansion modules, which shall be configurable on a module basis).

8.2.4.3 All I/O shall be mapped directly into dedicated analog I/O references.

8.2.4.4 Internal fault contacts shall be available in the ladder logic to alarm of analog error conditions.

8.2.4.5 Rack type analog I/O shall have an option to generate interrupts based on comparator values.

8.2.4.6 Input modules shall comply with the following:

Resolution:	Voltage: 16 bits	Current: 14 bits
Linearity:	+/- 0.02% of full scale over entire range.	
Temperature Coefficient:	+/- 5 PPM per degree C typical	
	+/- 15 PPM per degree C maximum, voltage	
	+/- 30 PPM per degree C maximum, current	
Conversion Rate:	2.4 to 2.8 msec for entire input module	

8.2.4.7 Input channels shall be expandable to 120 input channels per 17-slot rack.

8.2.4.8 Output modules shall comply with the following:

Resolution:	Voltage: 16 bits	Current: 14 bits
Linearity:	+/- 0.02% of full scale over entire range.	
Temperature Coefficient:		
Voltage:	+/- 10 PPM per degree C typical	
	+/- 20 PPM per degree C maximum	
Current:	+/- 10 PPM per degree C typical	
	+/- 30 PPM per degree C maximum	
Conversion Rate:	2.0 msec for entire output module	

8.2.5 Intelligent I/O Options

The programmable controller shall have intelligent I/O options available.

8.2.5.1 A specialized high-performance programmable microcomputer module shall be available to perform coprocessor functions. The programmable coprocessor shall be programmed with a powerful BASIC or "C" language interpreter to perform data acquisition, data storage and retrieval, real-time computing, and operator interface functions. The programmable microcomputer module shall occupy one slot in a rack. The programmable controller system shall be capable of holding up to 63 of these modules. The module shall have a minimum of 34 Kbytes of memory available for user programs and data storage. This memory shall be expandable to 640 Kbytes of battery-backed CMOS RAM. Two serial communication ports shall be provided on the module to interface to external devices. Both ports shall be software configurable to support either RS-232 and RS-422 cabling. The programmable microcomputer shall be dual tasking in order to perform communication (serial protocol) and BASIC tasks simultaneously on independent ports. Tasking shall be software configurable to utilized as:

- One Communications Port
- Two Independent Communications Ports
- One Communications Port and One BASIC Applications Port
- Two Basic Applications Port

8.2.5.2 Other intelligent modules for PAC communication shall be available:

- TCP/IP Ethernet Interface
- RTU Protocol
- CCM Protocol
- Genius®
- Fanuc I/O Link
- Series 90 Protocol (SNP)

8.3 Distributed Intelligent I/O

8.3.1 The I/O system shall be of a modular design. The modules shall, as much as possible, resemble terminal blocks commonly used in electrical panels. The small form-factor of the I/O Blocks (as they will be referred to in the remainder of this section) will include an electronic design that allows ease of installation and use in applications where a high degree of I/O distribution is desired.

8.3.2 In combination with the capability for I/O distribution the I/O system must offer unprecedented diagnostic capabilities for the system as a whole, for individual I/O Blocks and for individual circuits. The diagnostics shall be selectable, but once selected shall function automatically without additional user programming. Information provided by the diagnostics shall be made available to the user in English language message form.

8.3.3 The I/O Blocks shall have the capability to interface to at least the following common discrete control voltages:

- 115 Vac
- 125 Vdc (Sink or Source)
- 12/24/48 Vdc (Sink or Source)
- 5 Vdc Sink

and at least the following common analog control voltages or currents:

- 0 to 5 Vdc
- 0 to 10 Vdc
- -5 to +5 Vdc
- -10 to +10 Vdc
- 4 to 20 mA (1 to 5 Vdc)

Different control voltages may be handled by different types of I/O Blocks, but all I/O Blocks regardless of type shall use the same small form factor.

8.3.4 The following specialty I/O Blocks shall be available:

- Thermocouple
- High Speed Counter
- Power Monitor
- RTD

8.3.5 All addressing, option configurations and monitoring of all types of I/O Blocks shall be accomplished through a held device (referred to as Hand Held Monitor or HHM in the remainder of this section).

8.3.6 The Hand Held Monitor must be very portable and therefore shall be powered by rechargeable batteries. Each I/O Block shall have a connector to accommodate the HHM.

8.3.7 HHM functions shall include but not be limited to the following:

- Monitoring I/O states
- Forcing I/O states
- Monitoring I/O faults (diagnostics)
- Clearing I/O faults (to reset circuit operation)
- Selection of display language
- Manual execution of HHM selftest.
- Selection of all configuration and diagnostics
- Execution of discrete I/O Block Pulse Testing
- Addressing of all I/O Blocks
- Monitoring of Communications bus status/parameters
- Monitoring of registers and I/O in the CPU.

8.3.8 Communications between the controlling CPU and the I/O Blocks shall be via a proven reliable, token-passing, peer-to-peer serial link with automatic CRC error checking. The data communications baud rate shall be adjustable. A serial link is specified so that the physical connections between devices can be made with a shielded single twisted pair cable.

8.4 Remote I/O

8.4.1 I/O Types

The I/O System shall utilize standard I/O modules in standard I/O racks, on a high speed serial bus. A single bus controller in the local I/O rack must be able to communicate with up to 30 remote racks. In addition, it must be possible to place up to 31 bus controllers in a local I/O system.

8.4.2 Remote Racks and Bases

Each remote drop must be able to support:

- 1024 discrete I/O
- 64 analog I/O channels
- A programmable coprocessor module
- A graphic or pixel based operator interface module
- Up to seven expansion racks (total 8)

8.4.3 I/O Compatibility

The remote rack mounted I/O system must be completely compatible with the distributed intelligent I/O system, such that the two I/O systems can co-exist on the same bus. All the communications and diagnostic functionality of the intelligent distributed I/O bus must be maintained on the remote I/O bus.

9 Redundancy

There shall be the capability for a high availability system with redundancy at all levels – controller, Ethernet to HMI/Scada application, and I/O.

9.1 High Availability

The system shall consist of 2 CPU Systems connected with a high speed link that provides total synchronization and bumpless transfer of control.

9.1.1 The system must support Redundant IP for seemless Ethernet transfer between controllers.

9.1.2 The system must use integrated Control Memory Xchange for synchronization.

9.1.3 The system shall not penalize memory for redundancy

9.1.4 The system shall inflict only minimal overhead to the scan.

9.1.5 The system consists of the following features:

- CPU installation or removal shall not compromise the integrity of the system.
- Upon failure of a primary CPU, transfer of control to secondary CPU shall happen with a bumpless transfer of control as seen by the load.
- On-line repair capability with no degradation in system performance due to maintenance or repair.
- Same or different program in Primary or Secondary CPU for flexibility in case of failure.
- Symptom status bits and fault tables for ease of troubleshooting failures.
- Memory parity and checksums for system robustness.
- Wide range of I/O options as stated in I/O section of this document.
- Manual switching with push-button switch on Redundancy Communications Module for system.
- Support all variable types and 10mb memory.
- Support Floating Point Math.
- Single slot CPU
- Security for memory protection.
- Toggle for run and stop modes.
- Configurable data and program memory.

10 Vendor Requirements

10.1 Development Life Cycle

10.1.1 The vendor must have an established documented development procedure. This procedure must track customer requirements, development risk, and corrective action. The procedure must include a product validation cycle.

10.1.2 The vendor must have a formal and documented set of quality assurance procedures that are applied to the engineering design, development, and documentation of the software. The presence of a formal quality assurance department shall be required.

10.1.3 The vendor must also demonstrate that it's source code for the product is regularly archived with suitable backup.

10.1.4 The vendor must follow a documented configuration management system.

10.2 Product Life Cycle

10.2.1 The vendor must have an established product life cycle policy. Documentation of the product life cycle shall be available.

10.3 Manufacturer Qualifications

10.3.1 The manufacturer shall have shown a high commitment to product, manufacturing and design process quality. The manufacture shall be ISO9000 registered.

10.3.2 The manufacture shall have fully operational quality assurance and quality control programs in place. Complete documentation describing the quality assurance and quality plan shall be available.

10.3.3 A company who regularly manufactures and services this type of equipment shall offer the controller and/or I/O system and all of the corresponding components.

10.3.4 Vendor needs to be certified under the ISO 9001-2000 guidelines.

10.4 Preferred Vendor / Manufacturer

10.4.1 Pre-evaluation has identified that the PACSystems™ RX7i products from GE Fanuc Automation as the preferred solution. Any proposed solution must include at a minimum the functionality contained in the current commercially available version of these products.

10.4.2 Correspondingly, the preferred development environment for the control applications will be Proficy Logic Developer – Machine Edition from GE Fanuc Automation. Any proposed solution must include at a minimum the functionality contained in the current commercially available version of this software product.

10.4.3 Licensing will be provided to support XX simultaneous users and will include an annualized contract for Proficy™ GlobalCare Support.