

## ■ GENERAL

Multivariable Control Technology is gaining popularity in the process industry. It is now a unanimous conclusion that APC (Advanced Process Control) delivers sustainable and measurable benefits by simply stabilizing the plant to produce more and more stable product quality. The foundation for this conclusion is that control strategies should be developed from an understanding of the process and its nuances, a grasp of control systems over which APC will exist, the need for integrating it with wider plant objectives and a knowledge of base layer control loops.

Exasmoc, a product of Yokogawa-Shell alliance, combines these demanding necessities of the industry. It is a Multivariable Control package, which is built with the end users in mind. It is designed for use by process engineers working in a process plant with minimal advanced control theory knowledge.

Key Characteristic of Exasmoc:

Highest Uptimes in industry (i.e. Highest in industry)

Use of unmeasured disturbance models and grey box models to include a-priori process know how resulting in high robustness.

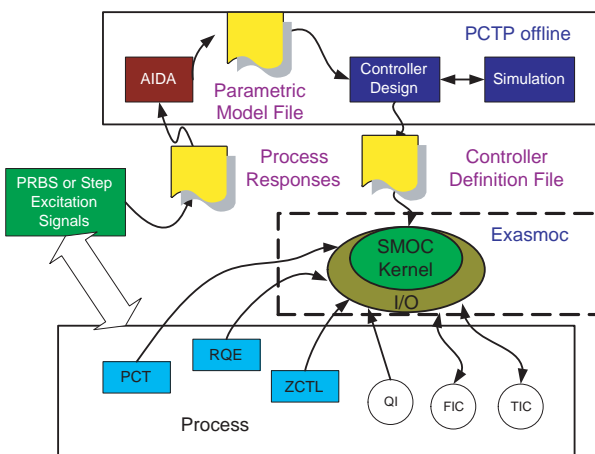
Easy to use design and simulation kit

Embedding in DCS

Easy integration with other plant information networking

Upgraded Web-based Human Interface.

PCTP (Exasmoc offline) and Exasmoc online operate in Windows 7/Vista/2003/2008 environments.



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## ■ FUNCTION SPECIFICATION

### A multivariable controller

Exasmoc periodically adjusts the level of several manipulated variables, so as to bring/keep the controlled variables at or within given targets, taking into account all the steady-state and dynamic interactions between variables.

### Set point and/or minimum/maximum objective

The objective of each controlled variable can be specified either as a set-point, or as the range between minimum and maximum constraints. The controller takes no action if the controlled variable lies within the limits.

### Selectable constraints on the control actions

Limits can be set on each manipulated variable, specifying absolute minimum, absolute maximum and maximum move size over one control step.

The limits on control valve position are recognized to avoid the controller “winding-up” beyond what process can achieve.

Controller can be made to respect valve gains.

Controller can continue to run in “crippled mode” after some manipulated variables cease to be available for control. Gains are adjustable online.

### Robust control

The controller has an ability to learn by distinguishing between process noise and process movement. It uses the Kalman filter.

### Process optimization

It is possible to minimize/maximize either any single variable (manipulated or controlled), or an economic function defined as a linear combination of any process variables. This optimization task has a lower priority than process control, and is performed under the condition that more degrees of freedom are available after all control objective are met.

### Main-controller and Sub-controller concept

When Multi-Variable Control is applied to a large process unit, a single large controller would be divided into several sub controllers to improve controller’s flexibility in operation and maintenance. The Exasmoc R3 and later enable control engineers to define sub-controllers.

A sub-controller will perform observation and control functions for a sub-set of manipulated and controlled variables. It will be possible to define different control period for different sub-controllers. Between 2 sub-controllers, there will be only intermediate variables (Intermediate variable links a process variable to another one.)

A main-controller will perform coordination between the sub-controllers. It will execute the feasibility check and optimization functions for the overall controller at steady state. The steady state functions will download manipulated variable horizon limits to the sub-controllers that will enforce consistent and optimized control strategy.

### Blending control

An in-line blender requires a sub-controller with the following special features.

1. All manipulated variables shall be ratios.
2. The only valid disturbance variables are non-manipulated blended components.
3. The sum of the ratios should be automatically kept as 1 (One).
4. The optimized control is performed at steady state only.

The Exasmoc R3 and later are capable of blending control.

### Non-linear optimization function

The Exasmoc R3 and later have a unique optimization function at steady state. It will be possible to define a non-linear (Bilinear form) optimization function. The Exasmoc R3 and later will handle classical margin maximization function. An example of non-linear function could be:

Maximize Feed \* sum of (Yield \* Product Price)

Where:

Feed and Yields are process variables and Product Prices are parameters

The control engineer will have the possibility to define multiple economic functions by offline and to select the one that is active by online. All economic function parameters are tunable by online.

### Online model gain update

The online tuning function is enhanced to include controller's model gain update. The update will not cause MV's bump.

It will be possible to update the gains remotely. For instance, the robust quality estimator can download new gains and trigger the gain update.

The online gain update is an essential feature of the "Green gas oil" control scheme.

### Specified execution order of application program

Special calculations for SMOC input and output variables are performed by application programs, which are executed in the specified order.

For example:

- (Step 1) To execute SMOC input calculations
- (Step 2) To execute SMOC control calculations
- (Step 3) To execute SMOC output calculations

The Exasmoc R3 and later enable control engineers to specify the execution order of application programs.

### Interface to Auto Plant Test function is provided

QuestPro is an auto plant test function.

Using Economic function, it allows to operate in the closed loop mode, which makes it easy to shorten the test period.

## ■ GENERAL CONFIGURATION

### ● Features

#### It handles feed-forward

For process variables which can be measured but not adjusted, and which are known to affect the controlled variables, anticipatory action can be taken upon a change in the "disturbance" variable.

#### Time delay compensation

In case of a delayed process (which has no response to an adjustment until a certain time has passed), a predictive technique is used which recognizes the presence of the delay and avoids over-reaction.

#### Speed tuner for manipulated variable adjustment

Manipulated variable control moves are always as small as possible, and the relative use of manipulated variable against each other and against the control objectives can be defined.

#### Defining weight of each control objective

If the problem becomes over constrained, not all the control objectives (setpoints or constraints) can be achieved. Then the objectives, which are first abandoned, or the relative offset on each objective, can be defined.

#### Online tuning via filters

Tuning filters are used to specify the desired speed of responding to set-point changes, compensating for disturbances in the controlled variables (or responding to inaccuracies in the controller's process model) as well as anticipating the effect of the measured disturbance variables.

#### Providing "Graceful degradation" of abnormal events

In case of loss of a manipulated variable (saturation, actuator failure, etc) optionally control can continue with the remaining manipulated variables (as best as possible).

In case of the loss of measurement of a controlled variable, control of other variables can optionally continue. "Open loop" control of the variable with missing measurement is then performed. Automatic checks are provided on the validity of online analyzer signals that the controller may be using.

#### OPC interface / Integration tool

Exasmoc can connect to any DCS or PLC via OPC interface to communicate with process input and output data. Device mode/Cache mode is selectable. Error processing according to the type of OPC error is prepared.

Integration function is also provided with to exchange data between Exasmoc controller and Exarqe estimator, Exasmoc controller and any OPC server.

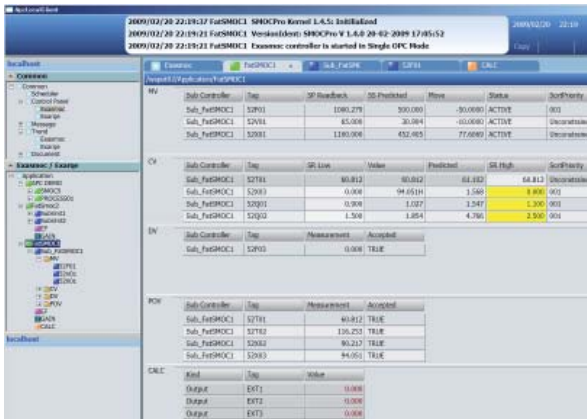
#### Calculation function

Using the input data of Integration tool, the calculation function executes the predefined calculation and outputs the results to the OPC server via Integration tool. Basic calculation (add/subtract/multiply/divide), arithmetic calculation (Sine/Cosine/Tangent/Log/Absolute/...), filtering, etc. are provided. Builder function and test function are also prepared to make it easy to implement.

## Human Interface

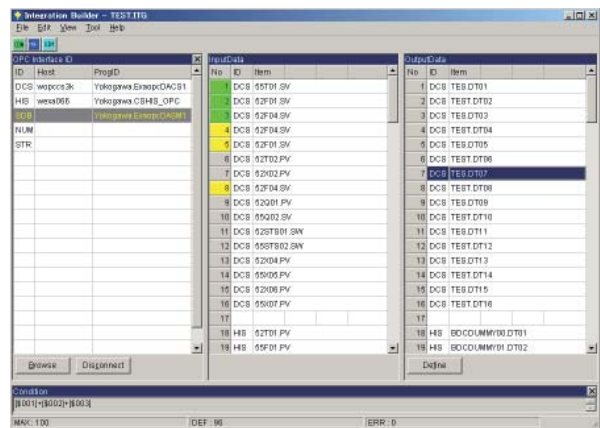
Human interface is fully upgraded from R4, which consists of Web-based style views. Each view is available not only in HIS, APC client PC but also Web PC via Web server.

- Main / Sub controller overview
- MV/DV/POV/CV/GAIN/EF views
- Trend view
- Historical message
- Integration tool
- Scheduler view
- Tree –view and multi-screen



Sub-controller Overview

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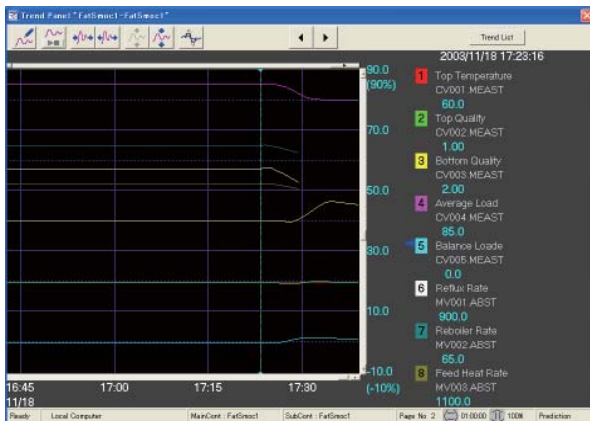
Integration Tool View

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### View customization

Overview of each system can be customized. The view can be used properly according to its usage, such as start-up of plants or steady-state operation, maintenance work or engineering work and so on.

- Specification of users who can access Overviews.
- Specification of SMOC data to be displayed on the Overview



Prediction Trend View

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## ■ AIDA Identification and Analysis

AIDA - Advanced Identification and Data Analysis – is the empirical dynamic process-modeling tool in the PCTP suite. AIDA uses process data from which it identifies linear dynamic models. AIDA makes available the powerful science and art of process model identification, in a process control relevant fashion.

### ● Features

**Data trending** – Enhanced and flexible trending capabilities such as stacked and shared plotting axes, zooming, auto-scaling, manual scaling, common scaling, scrolling, color customization, easy tag rearranging, tag trend locking, easily data value access from trends, segmentation and bad slicing from trends.

**Correlation Analysis** – The linear time response characteristics of the obtained trend data can be identified by carrying out auto-correlation analysis. Cross-correlation analysis is useful for identifying linear dynamic relation between two different data trends over a specified range of sampling lags. This is valuable for pre-screening input and output trend candidates for inclusion in the model building stage and for testing the quality of plant test data for fitting models. Cross-correlation analysis can also be valuable for identifying problem correlation between candidate trends and for detection feedback relationships in data that invalidates its use.

**Identification** – AIDA model estimation technology offers both FIR and parametric identification methods for determining process models. FIR allows for explicit estimation of input and output dynamic step responses. A priori delay and settling times can be specified for each input-output pair. AIDA provides statistical 95 percent confidence intervals for the estimated step responses.

Continuous time, low order transfer functions are fitted to the estimated FIR step response curves. This approach is an effective approach for response smoothing and obtaining good initial estimates for a parametric model fit to data. The low order models can directly fit to data, and statistical confidence intervals are provided for estimated parameters. AIDA uses efficient, State-of-the-art numerical computational solutions that permit solving large identification problems in minimal time.

Models estimated by AIDA are robust with regard to characteristics often encountered in process data that produce biased results. For example, the presence of unmeasured disturbances and significant noise can invalidate results if not accounted for. To eliminate this problem, AIDA uses data filtering. This is handled in a straightforward manner by providing a way to set a drifting flag and a smoothing filter constant. Defaults are provided to make these features transparent. AIDA yields unbiased models from data generated under closed loop conditions through the automated application of optimal filtering.

**Model validation** – For model validity checking, a range of different models for prediction comparison against actual data are available. It can generate future predictions in an open loop deterministic fashion, or mimic model prediction during control implementation with feedback bias updating correction. Residual trends and goodness-of-fit tests are available for auto- and cross-correlation analysis.

## ■ System Configuration

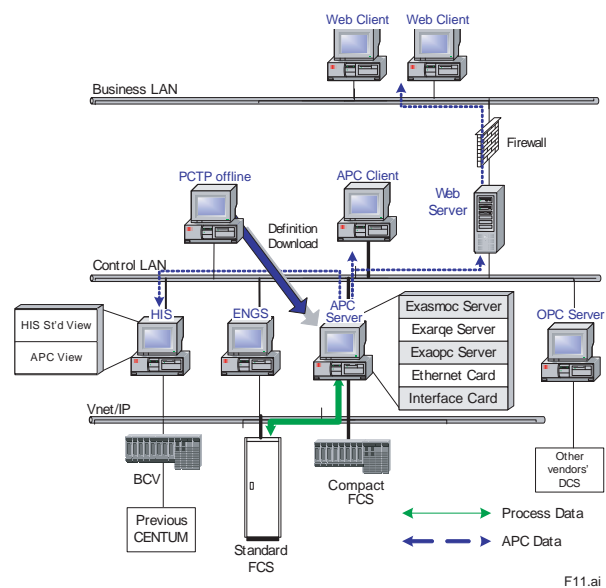
Exasmoc can connect to variety of DCSs and control systems. It reads the process data, performs the control action and writes the control outputs. All information is possible to access from HMI stations. APC function consists of the following stations:

- APC server: Exasmoc/Exarqe/Exaitg control execution.
- APC client : APC HMI interface
- Web server: Web server for APC HMI
- Web client : Web client function

APC station is connected to control stations via the VI/ VF Control Bus Interface Card, and it reads/writes tag data and receives process messages.

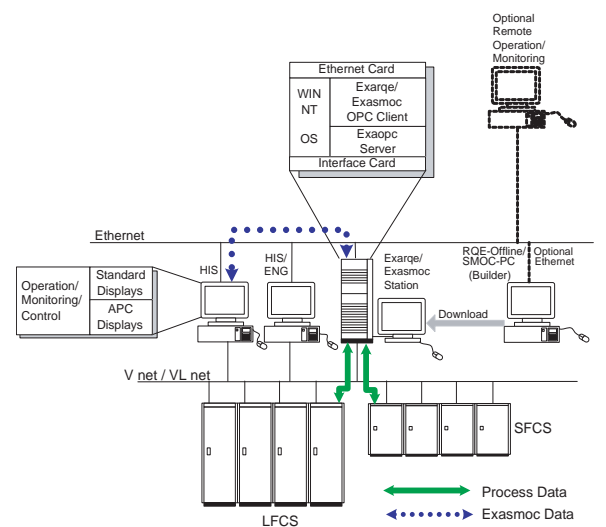
### CENTUM VP System

APC station is connected to control stations via the VI/ VF Control Bus Interface Card, and it reads/writes tag data and receives process messages.



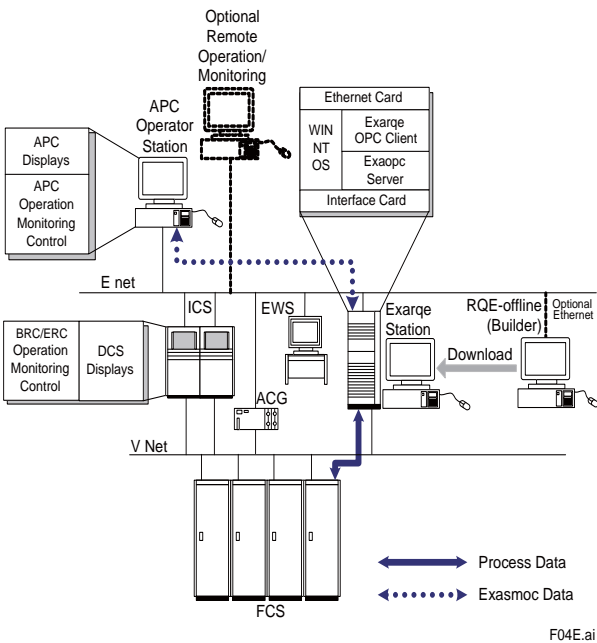
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### CENTUM CS 3000 System



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**CENTUM CS System**



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**APPLICATION CAPACITY**

Max. number of Exasmoc main controller: 20 controllers/station

Max. number of Exasmoc sub-controller: 20 controllers/main controller

- Control period: Min. 10 seconds.
- Number of MV: 100/subcontroller.
- Number of CV: 200/subcontroller.
- Number of DV: 50/subcontroller.
- Number of POV: 200/subcontroller.
- Number of EF: 100/subcontroller.
- Number of input compaction point: 100/controller.
- Number of output compaction point: 100/controller.

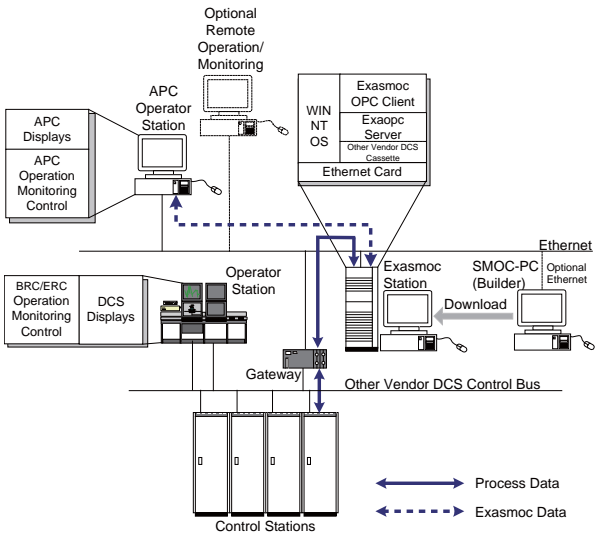
The name of Exasmoc controller: Up to 10 characters

Note: Actual number of controllers depends on the size of the controllers, memory size and CPU performance.

**Other vendor DCS System**

The Exasmoc station is connected to other vendors' DCS via OPC interface and Ethernet.

Connection test between Exasmoc with other vendor's DCS is indispensable in advance.



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## ■ OPERATING ENVIRONMENT

### Hardware

#### (APC server function)

CPU: Core 2 Duo 2.13 GHz or better  
 Main memory: 2 GByte or more (3 GByte recommended)  
 Disk capacity: 40 Gbyte or more recommended  
 Drive: DVD-ROM and CD-ROM drive  
 Monitor: SXGA (1280 x 1024 resolution), True Color  
 Mouse:  
 Communication device:  
 Ethernet-ready network card with 100 MBPS or more  
 VF/VI Control Bus Interface Card is required when connecting to CENTUM VP, CS 3000, CENTUM CS.  
 Graphics: DirectX 9 corresponding GPU and 128MB graphic memory

#### (APC client function)

CPU: Core 2 Duo 2.13 GHz or better  
 Main memory: 2 GByte or more (3 GByte recommended)  
 Disk capacity: 40 Gbyte or more recommended  
 Drive: DVD-ROM and CD-ROM drive  
 Monitor: SXGA (1280 x 1024 resolution), True Color  
 Mouse:  
 Communication device:  
 Ethernet-ready network card with 100 MBPS or more  
 Graphics: DirectX 9 corresponding GPU and 128 MB graphic memory

#### (APC Web server function)

CPU: Core 2 Duo 2.13 GHz or better  
 Main memory: 2 GByte or more (3 GByte recommended)  
 Disk capacity: 60 Gbyte or more recommended  
 Drive: DVD-ROM and CD-ROM drive  
 Monitor: SXGA (1280 x 1024 resolution), True Color  
 Mouse:  
 Communication device:  
 Ethernet-ready network card with 100 MBPS or more  
 Graphics: DirectX 9 corresponding GPU and 128MB graphic memory

#### (APC Web client function)

CPU: Core 2 Duo 2.13 GHz or better  
 Main memory: 2 GByte or more (3 GByte recommended)  
 Disk capacity: -  
 Drive: -  
 Monitor: SXGA (1280 x 1024 resolution), True Color  
 Mouse:  
 Communication device:  
 Ethernet-ready network card with 100 MBPS or more  
 Graphics: DirectX 9 corresponding GPU and 128 MB graphic memory

### Software

OS: Windows Server 2008 R2 (SP1, 64 bits)  
 Windows Server 2008 (SP2, 32 bits)  
 Windows 7 (SP1, 64 bits)  
 Windows Vista (SP2, 32 bits)

Note: In Web server, Server2008 and 2008 R2 are available.

The Exasmoc package and Windows must use the same language.

Others:  
 Internet Explorer 7.0/8.0/9.0  
 PCTP 2010 Build 1  
 Adobe Reader 10

Note: Exasmoc/Exarqe R4.03 APC client function is available from VP R5.01.00. In the previous HIS, R3.06 client (needs pre-test) and Web client are available.

### Interface Package

Exaopc R2.01 or later is required.

Note: - Exaopc R3.72.00 is required when Exaopc is installed on the same PC as Exasmoc.  
 - Exaopc is not available in Server 2008 up to now.

### OPC Interface

OPC interface connected to Exasmoc should support the following specification. Connection test in advance is recommended.

- OPC revision: Compliant to OPC Foundation specification.
- OPC DA 1.0a or later in case of single OPC server  
 OPC DA 2.05a or later in case of multiple OPC server
- OPC function: Synchronous read/write, Asynchronous read/write
- OPC performance: 100 data read and write per every second

**■ MODEL AND SUFFIX CODES**

		Description
<b>Model</b>	NTPS410	Exasmoc Multi-variable Model Predictive Control Package
<b>Suffix Codes</b>	-S0	Software License for Small Units (with Media) (*1)
	-S1	Basic Software License (with Media) (*2)
	-S5	Site License for Small Site (with Media) (*3)
	-S6	Site License for Medium Site (with Media)
	-S7	Site License for Large Site (with Media)
	0	Without Exasmoc online package (*4)
	1	With Exasmoc online package
	1	Always 1
<b>Option Code</b>	/□-ADU	Software License for Additional Unit (1 to 7 units) (*5) (□: 1 to 7)

- \*1: The size of controller for the small unit is less than 5 ins and 5 outs.
- \*2: Basic software license includes 1 copy of SMOC PC and AIDA.
- \*3: Site license includes 3 copies of SMOC PC and AIDA.  
Suffix Code "-S5": Small Site; Less than 100,000 BPD  
Suffix Code "-S6": Medium Site; 100,000 BPD to 199,999 BPD  
Suffix Code "-S7": Large Site; 200,000 BPD or larger
- \*4: At least one Exasmoc online package has to be quoted per PC.  
Exaopc package is required for Exasmoc to interface with CENTUM CS 3000.
- \*5: The number of additional unit(s) has to be entered in □ (i.e., enter "1" for the second unit).

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