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MTS Products

- | BOM N° or reference | Qty | DESIGNATION |
|---------------------|-----|--|
| | | <ul style="list-style-type: none"> • Project Management • Design and Drafting of MTS components, system assembly, and installation drawings. • Software engineering for Real Time Control software. • Manufacture, assembly, and in-plant checkout of controller hardware components. • Packing for shipment and shipment to site • Removal of existing controller hardware, installation of replacement equipment, system checkout at CEA, and training for CEA personnel in operation and maintenance. Training will be conducted at CEA by MTS personnel for 2 days total. • Installation and training by a MTS USA expert and a MTS France service engineer • System and software manuals, 2 sets • Spare boards – one each of the common boards (6 total) • One year warranty |

Local Purchases

BOM N° or reference	DESIGNATION
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- | | |
|---|---|
| • | Manual translation English to French (3950 €) |
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Local Services

BOM N° or reference	DESIGNATION
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- | | |
|---|--------------------------------|
| • | Local FSE assistance (2 weeks) |
| • | Local PE (40 hours) |



ADVANCED SYSTEMS GROUP

Azalee Controller Upgrade Proposal
for
COMMISSARIAT A L'ENERGIE ATOMIQUE

Offered by
MTS Systems Corporation

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Quotation Number	➤ ASG/1171 Revision C
Quotation Date	➤ 24 January, 2007
CEA Specification Number	➤ SEMT/EMSI/PT/07-001/A
Valid For	➤ 60 Days
Customer	➤ CEA Etablissement de Saclay 91191 GIF SUR YVETTE France
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Introduction:

MTS is offering a complete 6 Degree of Freedom (D.O.F) 469 D controller upgrade for the existing Azalee table system at CEA. Static support system controls are also included. This controller is noted for its ease of operation. It permits faster set up and tuning of new specimen configurations. This controller is in wide use today at over 20 seismic table installations. The new controller will be configured to allow future use of ScramNet connections for hybrid testing.

The scope of the project includes; design and manufacture of all 469 D components, removal of existing control hardware (does not include disposal of the replaced components), complete installation of all delivered material, and training in system operation. The training will be done immediately after installation. Follow up training can be offered as an additional cost if needed.

The existing static support controls will be replaced with an interface to the system digital I/O. The table support adjustment will become an automated function of the new controller. It is important that the existing air supply, solenoids, and sensors installed are operational.

See attachment A for acceptance test protocol.



System Bill of Material

1.0. System Services (*quantity = lot*). Price includes the following:

- 1) Project Management \$14,370 USD
- 2) Design and Drafting of MTS components, system assembly, and installation drawings. \$41,690 USD
- 3) Software engineering for Real Time Control software. \$43,500 USD
- 4) Manufacture, assembly, and in-plant checkout of controller hardware components. \$238,150 USD
- 5) Packing for shipment and shipment to site included in item #4
- 6) Removal of existing controller hardware, installation of replacement equipment, system checkout at CEA, and training for CEA personnel in operation and maintenance. Training will be conducted at CEA by MTS personnel for 2 days total. \$61,408 USD
- 7) System and software manuals, 2 sets \$11,612 USD
- 8) Spare boards – one each of the common boards (6 total) \$10,842 USD
- 9) One year warranty included in item #4

Price: \$421,572 USD

1.1. MTS 469D Digital Control System

The MTS 469D Digital Control system will provide for simpler shake table tuning, system operation, and test execution. It will not improve on basic system performance (acceleration, velocity and displacement) but will permit faster set up and more 'tools' to handle difficult specimens.

1.1.1. Six Degree of Freedom Table Controller:

a) Computer Hardware

- 1) 2.4 Ghz minimum Pentium 4 PC with 512 MB RAM or equivalent.
- 2) 40 GigaByte minimum Hard Disk
- 3) 20-inch color flat panel monitor
- 4) R/W CD-ROM Drive
- 5) Inkjet color printer
- 6) Ethernet Remote network interface 10/100 Mbps

Replace with
5500 or
5110

b.) Real-Time Controller using 493 series MTS hardware:

- 1) 2434 Power PC

- 2) 8 Digital Universal Conditioners for Actuator Stroke
- 3) 12 Digital 3-Stage Valve Drivers for Horizontal Actuator Servovalves and 12 Digital 3 - Stage Valve drivers for Vertical Actuator Servovalves
- 4) 8 Digital Universal Conditioners for Actuator Delta-P
- 5) 11 Digital Universal Conditioners for Table accelerometers
- 6) D/A Channels for DOF Acceleration, Velocity, and Position Readouts
- 7) D/A Channels for selectable Readouts
- 8) A/D Input Channels for external Program Inputs
- 9) 6 A/D Input Channels for arbitrary inputs
- 10) Digital I/O for controlling static support air bags, HSM, auxiliary warning lights
- 11) Windows operating system

c.) Modification of existing system cables to actuator and table transducers.

Note: This proposal assumes that all existing actuator and table transducers are in good working condition. The existing Hydraulic control panel will be used to control the pumps and hydraulic service manifold.

1.1.2. Real Time Control Software for the six degrees of freedom

MTS Seismic Digital Control software provides an advanced graphical user interface, or GUI. Full functionality is provided through the GUI for system tuning, test set up and operation, table data acquisition, and advanced high level adaptive control for high fidelity earthquake waveform reproduction. The control software includes:

The following set of High Level Fixed Control Techniques

Three Variable Control (TVC) for high fidelity reproduction across a wide bandwidth. TVC includes a reference generator and velocity computer for deriving command and feedback signals in displacement, velocity, and acceleration. TVC is necessary due to the wide bandwidth associated with seismic time histories.

Delta Pressure Stabilization, for effectively dampening oil column compliance to allow for higher gain settings across a wider bandwidth. The ability to maintain high gain settings without decreased stability is critical for high fidelity seismic waveform reproduction.

The following set of patented MTS Adaptive Control Techniques

Amplitude Phase Control (APC) for automatic correction of amplitude and phase errors during sine wave testing. A network of time domain digital filters measures the system input and output to detect errors in amplitude and phase. The input signal is then automatically scaled by the inverse of the amplitude error and shifted by the negative of the phase error. APC quickly reacts to changes in the system to maintain minimal error in amplitude and phase even when changing system dynamics are present.

Adaptive Harmonic Cancellation (AHC) for control and elimination of harmonic distortions during sine wave testing. AHC is based upon the technologies developed in the science of active noise cancellation. AHC automatically eliminates unwanted harmonics by adding a signal with exactly the right phase and amplitude such that the harmonic is canceled. AHC automatically adjusts to changes in the system or specimen response.

Note: Amplitude Phase Control and Adaptive Harmonic Cancellation can be used simultaneously for reducing linear and non-linear errors when performing sine wave testing.

Adaptive Inverse Control (AIC) for reducing linear distortions during random waveform testing. AIC uses a digital filter to measure the frequency response function of the system. The command signal is then scaled by the inverse of this function so that the overall frequency response is closer to unity. AIC automatically adjusts to changes in the system or specimen response.

On Line Iteration (OLI) for reducing the affect of non-linear distortion causes during random wave form testing when the highest levels of waveform fidelity are required. OLI uses the digital filters of AIC to measure the frequency response function of the system while the drive file is played out. OLI then modifies the drive file and repeats the process. The drive file is modified, or iterated, a number of times until the output of the system closely matches the original drive file.

Command Function Generation

Test waveforms that can be generated by the internal function generators include:

Cyclic: Square, triangle, and sine with adjustable amplitude and frequency. Sine sweep and dwell capability is also provided. Sine step programming with frequency or time specification.

Random: Band-limited and shaped noise with adjustable RMS amplitude. Shapes include flat, $(1/f)^2$, $(1/f)$, f , $(f)^2$.

File: Any file of arbitrary points can be played out. Quadratic interpolation is used to up sample to the control update rate. The file can be generated using MTS STEX3 Software, other commercially available data analysis packages or selected from the many thousands of earthquake time histories available in the research community. MTS supplies file player data format interfaces to MATLAB; therefore, allowing the use of many complex function generation operations, such as sine beat, mixed sine and random, decaying sine, multiple sinusoids, etc.

Data Display

A number of internal and external signals are available for display for monitoring and diagnostic purposes. These include table command and feedback in displacement, velocity, and acceleration. Signals can be observed in the following manner:

Digital oscilloscope: Displays two signals simultaneously on the computer screen in real time. Signals can be shown in time, frequency, or phase (X-Y) domains. However, the real-time controller has a built-in oscilloscope that is available at all times.

Digital meter: Displays the current value of a signal, its maximum and minimum achieved values, and its peak and valley achieved values.

Digital Frequency Response Function Plotter: Used to display one or two transfer functions in phase or amplitude versus frequency. This display is extremely useful for test setup.

In addition, a time- & date-stamped status log is maintained of all machine operations, limit detector trips, etc. The log is maintained on disk and can be examined at any time.

Additional functionality

The control system software and Graphical User Interface provide the user with the ability to perform a number of very important additional functions.

Data acquisition of all internal and external signals to digital file is provided. A file translator is also provided to convert from the acquired binary format to a text format suitable for transfer to many other analysis packages. There is a special interface function supplied for MATLAB that allows MATLAB to read these specific data files.

All electronic hardware is accessed through the graphical user interface for purposes of calibration. All calibration parameters can be stored to a digital file.

A test parameter file can be created to record the test specific settings for a given test. These may include settings of the function generator, system gain, TVC settings, among others. Multiple test parameter files can be stored.

Any internal or external signal can be used for limit detection purposes. The signal, action to be taken, upper and lower limits, and persistence are selected through the GUI.

An access protection password system allows only qualified operators to change critical system parameters to protect the system from unwanted changes.

1.2 Pneumatic Static Support Assembly

Replacement Static Support controls to automatically balance specimen plus table mass to maximize available hydraulic actuation force.

Customer Responsibilities

Power

- Provide adequate, fused electrical power for table controller consoles. Control console power should be free of power transients. Power requirements are estimated to be 6 KVA

Air Conditioning

- Provide an adequately air conditioned room for the electronic consoles.

Access

- Provide free access to the installation site for MTS installation engineers.

Hazards

- Servohydraulic test systems are designed for maximum force and velocity performance. They should be considered hazardous. Appropriate safety considerations should be implemented when using servohydraulic test systems.

Disposal of all replaced items



Special Terms and Conditions

Taxes, Duties, & Fees

- Purchaser will pay any necessary national or local sales tax, import duties or customs fees.

Special Charges

- Landing costs or any required certificates of origin, consular invoices or any other documents issued in the country of origin which may be required for importation of goods to the country of destination shall be borne by the purchaser.

Customs

- Purchaser will perform customs clearance and provide inland transportation to installation site.

Delivery

Export License

- Delivery is contingent upon the issuance of an Export License to MTS.

Shipment Schedule

- Equipment ready for shipment 6 months ARO

Terms

Payment

- 40% net 30 days, after receipt of order.
40% net 30 days, upon presentation of shipping documents.
20% net 30 days upon final acceptance.

Packing Method

- Ocean freight

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Section 1 -- Table empty

- 1.0. This section of the validation tests will demonstrate the operation of the empty table. Data acquisition will monitor the table program, displacement, force, and average acceleration. The test record will be used to document the normal operations such as applying hydraulic pressure (test 1.0.1), moving the table from Park to Normal (test 1.0.2), and the vibration noise on the static table (test 1.0.3). Testing will include sinusoidal excitation in each axis and control mode to demonstrate the table performance capability (test 1.1.x, 1.2.x, 1.3.x) and signal waveform quality. Random excitation tests will be performed using a digital controller to measure the system transfer function, apply iterations, and generate a seismic test is each control axis.
- 1.0.1 Measure and record the table acceleration and displacement when turning on HSM from Low to High. Repeat the start and stop to verify the amount of hydraulic shock and audible noise. Target is less than 0.1 g table acceleration.
- 1.0.2 Measure and record the table acceleration and displacement while moving from "Park" to "Normal" position, and again returning to the Park position. Repeat the movement function to verify stability and noise level. Target is no "pitch motion" or oscillations.
- 1.0.3 Measure and record the table acceleration in "Normal" position without program to define "quiescent noise" level. Target is less than 0.05 g acceleration noise.
- 1.1.1 Measure and record the feedbacks to verify Vertical (Z) displacement and waveform quality.
- 1.1.2 Measure and record the feedbacks to demonstrate vertical velocity and waveform quality.
- 1.1.3 Measure and record the feedbacks to demonstrate vertical acceleration and waveform quality.
- 1.1.4 Measure the Vertical transfer function in acceleration control mode. Excite the table with random program using a digital system to obtain response for calculating transfer function. Perform a normal iteration process with the digital controller to verify convergence to desired profile.
- 1.1.5 Use the corrected test profile from test 1.1.4 to excite the table with a seismic test to verify comparison of desired spectrum.
- 1.2.1 Measure and record the feedbacks to verify Lateral (Y horizontal) displacement and waveform quality.
- 1.2.2 Measure and record the feedbacks to demonstrate lateral velocity and waveform quality.
- 1.2.3 Measure and record the feedbacks to demonstrate lateral acceleration and waveform quality.
- 1.2.4 Measure the Lateral transfer function in acceleration control mode. Excite the table with random program using a digital control system to obtain a response for calculating transfer function. Perform a normal iteration process with the digital controller to verify convergence to desired profile.
- 1.2.5 Use the corrected test profile from test 1.2.4 to excite the table with a seismic test to verify comparison of desired spectrum.

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- 1.3.1 Measure and record the feedbacks to verify Longitudinal (X horizontal) displacement and waveform quality.
- 1.3.2 Measure and record the feedbacks to demonstrate longitudinal velocity and waveform quality.
- 1.3.3 Measure and record the feedbacks to demonstrate longitudinal acceleration and waveform quality.
- 1.3.4 Measure the Longitudinal transfer function in acceleration control mode. Excite the table with random program using a digital control system to obtain a response for calculating transfer function. Perform a normal iteration process with the digital controller to verify convergence to desired profile.
- 1.3.5 Use the corrected test profile from test 1.3.4 to excite the table with a seismic test to verify comparison of desired spectrum.
- 1.4.1 Demonstrate tri-axial capability. Excite the table using sine wave on the vertical, lateral, and longitudinal axes in phase.
- 1.4.2 Demonstrate six D.O.F. capabilities. Excite the table with random program using the digital control system to program the vertical, lateral, and longitudinal axis, also program pitch, roll, and yaw to zero.

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Section 2 -- 15 ton load

- 2.0. This section of the validation tests will demonstrate the operation of the table with a 15 ton rigid mass securely attached. Data acquisition will monitor the table program, displacement, force, and average acceleration. The test record will be used to document the normal operations such as applying hydraulic pressure (test 2.0.1), moving the table from Park to Normal (test 2.0.2), and the vibration noise on the static table (test 2.0.3). Testing will include sinusoidal excitation in each axis and control mode to demonstrate the table performance capability (test 2.1.x, 2.2.x, 2.3.x) and signal waveform quality. Random excitation tests will be performed using a digital controller to measure the system transfer function, apply iterations, and generate a seismic test in each control axis (test 2.1.5, 2.2.5, 2.3.5).
- 2.0.1 Measure and record the table acceleration and displacement when turning on HSM from Low to High. Repeat the start and stop to verify the amount of hydraulic shock and audible noise. Target is less than 0.1 g table acceleration.
- 2.0.2 Measure and record the table acceleration and displacement while moving from "Park" to "Normal" position, and again returning to the Park position. Repeat the movement function to verify stability and noise level. Target is no "pitch motion" or oscillations.
- 2.0.3 Measure and record the table acceleration in "Normal" position without program to define "quiescent noise" level. Target is less than 0.05 g acceleration noise.
- 2.1.1 Measure and record the feedbacks to verify Vertical (Z) displacement and waveform quality.
- 2.1.2 Measure and record the feedbacks to demonstrate vertical velocity and waveform quality.
- 2.1.3 Measure and record the feedbacks to demonstrate vertical acceleration and waveform quality.
- 2.1.4 Measure the Vertical transfer function in acceleration control mode. Excite the table with random program using a digital system to obtain response for calculating transfer function. Perform a normal iteration process with the digital controller to verify convergence to desired profile.
- 2.1.5 Use the corrected test profile from test 2.1.4 to excite the table with a seismic test to verify comparison of desired spectrum.
- 2.2.1 Measure and record the feedbacks to verify Lateral (Y horizontal) displacement and waveform quality.
- 2.2.2 Measure and record the feedbacks to demonstrate lateral velocity and waveform quality.
- 2.2.3 Measure and record the feedbacks to demonstrate lateral acceleration and waveform quality.
- 2.2.4 Measure the Lateral transfer function in acceleration control mode. Excite the table with random program using a digital control system to obtain a response for calculating transfer function. Perform a normal iteration process with the digital controller to verify convergence to desired profile.

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- 2.2.5 Use the corrected test profile from test 2.2.4 to excite the table with a seismic test to verify comparison of desired spectrum.
- 2.3.1 Measure and record the feedbacks to verify Longitudinal (X horizontal) displacement and waveform quality.
- 2.3.2 Measure and record the feedbacks to demonstrate longitudinal velocity and waveform quality.
- 2.3.3 Measure and record the feedbacks to demonstrate longitudinal acceleration and waveform quality.
- 2.3.4 Measure the Longitudinal transfer function in acceleration control mode. Excite the table with random program using a digital control system to obtain a response for calculating transfer function. Perform a normal iteration process with the digital controller to verify convergence to desired profile.
- 2.3.5 Use the corrected test profile from test 2.2.4 to excite the table with a seismic test to verify comparison of desired spectrum.
- 2.4.1 Demonstrate tri-axial capability. Excite the table using sine wave on the vertical, lateral, and longitudinal axes in phase.
- 2.4.2 Demonstrate six D.O.F. capabilities. Excite the table with random program using the digital control system to program the vertical, lateral, and longitudinal axes, also program pitch, roll, and yaw to zero.

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Section 3 -- 30 ton load

- 3.0. This section of the validation tests will demonstrate the operation of the table with a 30 ton rigid mass securely attached. Data acquisition will monitor the table program, displacement, force, and average acceleration. The test record will be used to document the normal operations such as applying hydraulic pressure (test 3.0.1), moving the table from Park to Normal (test 3.0.2), and the vibration noise on the static table (test 3.0.3). Testing will include sinusoidal excitation in each axis and control mode to demonstrate the table performance capability (test 3.1.x, 3.2.x, 3.3.x) and signal waveform quality. Random excitation tests will be performed using a digital controller to measure the system transfer function, apply iterations, and generate a seismic test in each control axes (test 3.1.5, 3.2.5, 3.3.5).
- 3.0.1 Measure and record the table acceleration and displacement when turning on HSM from Low to High. Repeat the start and stop to verify the amount of hydraulic shock and audible noise. Target is less than 0.1 g table acceleration.
- 3.0.2 Measure and record the table acceleration and displacement while moving from "Park" to "Normal" position, and again returning to the Park position. Repeat the movement function to verify stability and noise level. Target is no "pitch motion" or oscillations.
- 3.0.3 Measure and record the table acceleration in "Normal" position without program to define "quiescent noise" level. Target is less than 0.05 g acceleration noise.
- 3.1.1 Measure and record the feedbacks to verify Vertical (Z) displacement and waveform quality.
- 3.1.2 Measure and record the feedbacks to demonstrate vertical velocity and waveform quality.
- 3.1.3 Measure and record the feedbacks to demonstrate vertical acceleration and waveform quality.
- 3.1.4 Measure the Vertical transfer function in acceleration control mode. Excite the table with random program using a digital system to obtain response for calculating transfer function. Perform a normal iteration process with the digital controller to verify convergence to desired profile.
- 3.1.5 Use the corrected test profile from test 3.1.4 to excite the table with a seismic test to verify comparison of desired spectrum.
- 3.2.1 Measure and record the feedbacks to verify Lateral (Y horizontal) displacement and waveform quality.
- 3.2.2 Measure and record the feedbacks to demonstrate lateral velocity and waveform quality.
- 3.2.3 Measure and record the feedbacks to demonstrate lateral acceleration and waveform quality.
- 3.2.4 Measure the Lateral transfer function in acceleration control mode. Excite the table with random program using a digital control system to obtain a response for calculating transfer function. Perform a normal iteration process with the digital controller to verify convergence to desired profile.

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- 3.2.5 Use the corrected test profile from test 3.2.4 to excite the table with a seismic test to verify comparison of desired spectrum.
- 3.3.1 Measure and record the feedbacks to verify Longitudinal (X horizontal) displacement and waveform quality.
- 3.3.2 Measure and record the feedbacks to demonstrate longitudinal velocity and waveform quality.
- 3.3.3 Measure and record the feedbacks to demonstrate longitudinal acceleration and waveform quality.
- 3.3.4 Measure the Longitudinal transfer function in acceleration control mode. Excite the table with random program using a digital control system to obtain a response for calculating transfer function. Perform a normal iteration process with the digital controller to verify convergence to desired profile.
- 3.3.5 Use the corrected test profile from test 3.2.4 to excite the table with a seismic test to verify comparison of desired spectrum.
- 3.4.1 Demonstrate tri-axial capability. Excite the table using sine wave on the vertical, lateral, and longitudinal axes in phase.
- 3.4.2 Demonstrate six D.O.F. capabilities. Excite the table with random program using the digital control system to program the vertical, lateral, and longitudinal axes, also program pitch, roll, and yaw to zero.