REQUIREMENTS SPECIFICATION

FOR THE MODULE LEVEL

CONTROLLER

PSI PROJECT NO. 3509

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Preamble

The objective of this report is to specify the requirements for an extensible Module Level controller.

The requirements specification contained herein reflects the information gleaned from the listed documents as well as the information received from conversations with FSI engineers at the Chaska and Lubbock facilities.

The scope of this set of specifications may or may not be met by a single candidate system when an attempt is made, during Phase II, to identify control system components that would satisfy these specifications. During Phase II, the life cycle cost model will be utilized to evaluate various candidate systems and the relative merits of each candidate configuration. However, if the requirements are not properly specified in Phase I, it will become an impossible task to make intelligent tradeoffs among the potential configurations.

REQUIREMENTS FOR MODULE LEVEL CONTROLLER

1.1 Identification

Module Level Controller for Semiconductor Processing Equipment.

1.2 System overview

In a maximum system, a Workcell (level) Controller will coordinate the operation of dissimilar Cluster Level controllers. An example of a maximum system is shown as the System Reference Model in Paragraph 3. I. If a Cluster Controller exists, it will coordinate the operation of Module Level Controllers of similar pieces of processing equipment. The Module Level Controllers will control all operations of the semiconductor processing equipment through the storing and sequencing of process information. Input signals will modify the control sequence. output signals will be used to control the valves, motors, robot arms, etc. in the processing equipment. The requirements of the specific application will determine the presence or absence of a Cluster or Workcell Controller. It is feasible for a Module Level Controller to control other Module Level Controllers.

In a minimum system, the Module Level Controller may have to stand completely alone with its processing module and it would then require at least an operator interface along with data storage for data logging and program retrieval.

1.3 Document Overview

This requirements specification for a Module Level Controller is to be used for planning purposes to develop control systems for FSI over the next five years.

2 Applicable Documents

2.1 The following documents were referenced in developing the requirements specification.

<u>FSX</u> <u>Documents</u>

CHEMFIL 1000 - Chemical Delivery System — Operator and Maintenance Manual — 501026-001
INTEL D2 CHEMFIL — Chemical Delivery System — Software Manual - 501191-003
MERCURYOC — Acid Processing System — Operator's Guide - 501028-002
MERCURY — Software Manual — Version 4.12 - 501028-300
SATURN MP — Acid Processing System — Operator's Guide — 500539-006
Operations Guides for FSI Products :

- Neptune
- Phoenix
- Saturn
- Megasonic
- Mercury

<u>Semiconductor Industry Documents</u>

SEMI Standard Mechanical Interface (SMIF) — Document #1332

SEMI Cassette Transfer Parallel I/O Interface specification

SEMI Generic Equipment Modules for Effective Factory Automation

1990 SEMI International Standards — Equipment Automation
SEMI MESC Cluster Tool User—Vendor Workshop, Nov 2, 1989
MESC Cluster Tool Communication — Draft Version 1.1

MESC Communication Workshop — Jan. 10, 1990

SEMATECH President's Day Volumes 1-3

SEMATECH Generic Cell Controller Development Program

STEP/Cluster Tool Communications

IEEE/ANSI standards

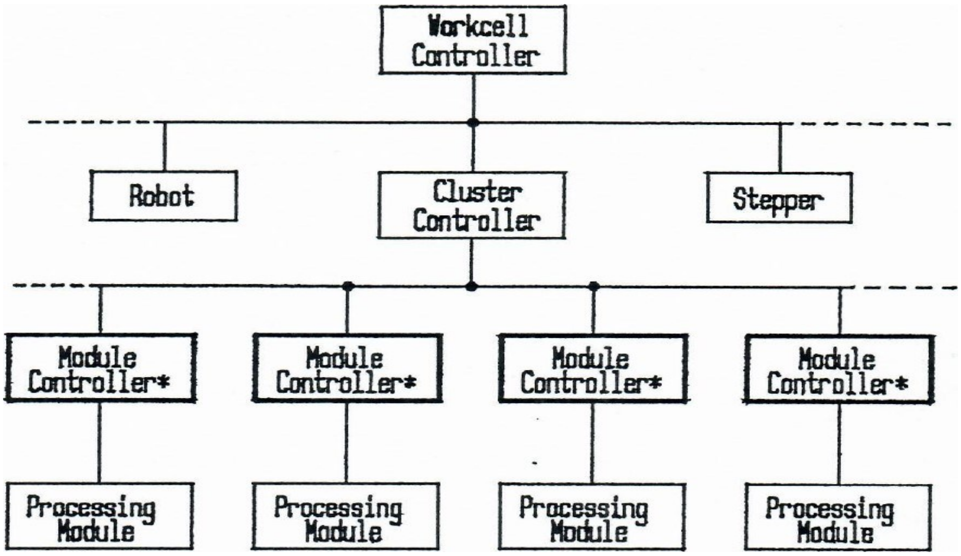
- Ethernet 802.3 CSMA/CD Access Method and Physical Layer Specifications

Other Documents

- Federal Communications Commission Regulations, Part 15

3 System Specifications

3.1 System Reference Model



The Module Controller is the item being specified in this document.

3.2 Characteristics

The Module Level Controller is to be a real-time control system. It must receive the input signals, make decisions, and respond with the necessary control signals in several milli—seconds. The Module Level Controller handles multiple tasks including safety, failure detection, and communications with the next higher level controller. The Cluster Controller has similar responsibilities but responds on the order of tenths of seconds.

3.2.1 Performance Characteristics

3.2.1.1 Initialization Mode

In this mode, the program in the Module Level Controller will be verified. The hardware that is connected to the controller will be calibrated. Control variables will be adjusted. Self-test programs will be run. Hardware will be initialized to a predetermined safe state.

3.2.1.2 Recovery Mode

All Module Level Controllers will power up in recovery mode and will report the status of the last atomic transaction, as retained in non-volatile memory, to the next higher level controller.

3.2.1.3 Test and Maintenance Mode

In this mode, the Module Level Controller will be directed to step through functional tasks to allow testing of the connected hardware for proper operation. This is a privileged mode of operation that may bypass safety features.

3.2.1.4 Stand—alone Mode

In this mode, the Module Level Controller will operate independent of other higher level controllers.

3.2.1.5 Workcell / Cluster Mode

The Workcell / Cluster mode of operation will be utilized when a supervising controller issues the operational commands to a subordinate Module Level Controller(s) . The Cluster Controller is expected to interface with the Workcell Controller through one LAN and with the Module Level Controllers through another closed subsystem LAN.

3.2.2 External Interface Requirements

3.2.2.1 Workcell Controller External Interface Description

The Workcell Controller and its subordinate Cluster Controllers or Module Level Controllers will be connected through a closed Ethernet LAN. current SEMI and Sematech standards dictate Ethernet but will not preclude other possible network interfaces.

3.2.2.2 Analog Signals External Interface Description

The Module Level Controller will have the capability of interfacing to analog signals in the -10 to +10 volt range with an option for 4 to 20 milliamp current loops. All signal conditioning to meet the requirements will take place as specified in 3.2.2.2.1. The maximum signal sampling rate will not exceed 1 KHz. Analog signals in the same voltage range may be generated at corresponding signal rates. 12-bit conversion specifications are expected. Outputs will typically be set to the minimum value at initialization.

3.2.2.2.1 Analog Signal Conditioning External Interface Description

Inputs to A/D converters requiring scaling should be made through programmable gain amplifiers . Gains of .1, .5, 1, 10, 100, and 1000 should be available. Signal translation and isolation will be provided by differential input amplifiers, active filtering, and sample and hold circuitry as necessary.

3.2.2.3 Digital Signal External Interface Description

The Module Level Controller will expect discrete signal inputs from various external devices. The number of these signal lines may exceed 256. The maximum data transfer rate will not exceed 256 Kbytes per second.

3.2.2.3.1 Digital Signal Conditioning External Interface Description

The Module Level controller will expect digital input in the range of 0 to 24 vdc as well as TTL levels. Signal conditioning will include translation, scaling, and noise isolation. The Module Level Controller will need to have the capability of driving outputs between GND and 24 vdc with a minimum drive current of 250 milliamps. Output signals will be driven to a safe known state on power up. Each input signal link will be paired with an output signal link to allow system diagnostics and safety monitoring of the system.

3.2.2.3.2

The Module Level Controller will have the capability of responding to 16 channels of external interrupts. A priority interrupt scheme will be implemented as required by the application. Interrupt signal inputs will be functional for time critical events requiring action with high priority in the 1 to 50 microsecond time range.

3.2.2.3.3 Counter/Timer Input/Output External Interface Description

The Module Level Controller will provide for up to 8 counter/timer channels (input—output pair) having 16—bit resolution and the capability for cascading to provide long time delays. Inputs and outputs will be conditioned for signals in the range of 0 to 24 vdc for external use as specified in 3.2.2.3.1.

3.2.2.4 Module User Interface — External Interface Description

The external user interface output from the Module Level Controller may be a combination of the following: LEDs, LCD display, CRT terminal screen, or VGA graphics screen. The inputs may be front panel keys, touch screen, keyboard or inputs from a track ball. User control may also be effected from a virtual terminal at the next higher level.

3.2.2.5 External Equipment Interface

The external equipment interface unit will optionally allow for a SCSI and/or IEEE 488 interface, serial and parallel port(s), and additional LAN interfaces for instrumentation or other external equipment.

3.2.2.6 Terminal External Interface Description

The Module Level Controller will have an external interface through a serial port. The interface standard utilized will be RS 232C, RS 422, or RS 485. This interface may be utilized during test and maintenance mode to provide a physical terminal interface for exercising the system.

3.2.3 Physical Characteristics

3.2.3.1 Dimensional Limits

The size of the Module Level Controller will allow for it to be incorporated either with the wafer processing equipment or in the service chase. The maximum target volume for the Module Level Controller is approximately the size of an AT rack mount enclosure. The ability to use the same circuit boards in different enclosures is desirable.

3.2.3.2

The power supplied to the controller will be a maximum 24 vdc at 10 amps. Point of use power supply regulation is anticipated. If a video terminal is required, a separate source of power will be necessary. Power necessary for driving relays and actuators will be provided by the signal conditioning interface.

3.2.4 System Quality Factors

3.2.4.1 Reliability Requirements

The mean time between failure (MTBF) is 3,000 hours with a goal of 10,000 hours.

3.2.4.2 Maintainability

Real or virtual terminal capability for troubleshooting and diagnosis is necessary. Quick release circuit board connectors will be utilized; a circuit board will be the smallest replaceable component. The repair/ replacement of IC components within the controller will take place only at the factory (FSI).

3.2.4.3 Availability

The design of the Module Level controller will provide for graceful degradation of the process. Graceful degradation will be accomplished by keeping the status of current tasks in non—volatile memory. Upon resumption of the process, the Module Level Controller will enter the recovery mode of operation. The controller will allow for changing its operational mode without affecting the sub—network of which it is a member. Watchdog timers will be utilized for fault detection.

3.2.5 Environmental Conditions

The controller will function correctly in both the clean room and the service chase at temperatures up to 40 degrees Celsius. The controller will function correctly in a noisy electrical environment.

3.2.6 Flexibility and Extensibility

Flexibility and extensibility will be provided through the selection of appropriate functional cards to accomplish the external interface requirements of paragraph 3.2.2 as required by the application.

3.3 Additional Design Issues

3.3.1 Materials

Materials used will be consistent with clean room standards.

3.3.2 Electromagnetic Radiation

The Module Level Controller will meet the requirements of a digital device as required by the Federal Communications Commission (FCC).

3.3.3 Interchangeability

Vendor stability will be provided through the use of multiple sources for components, such as standard cards, chips, etc.

3.3.4 Safety

Emergency Power Off capabilities will be provided on the Module Level Controller. Watchdog timers will be used for fault detection. Power failure recognition will be provided.

3.3.5 Human Engineering

The layout of the controller will use the concept of a grid matrix for easy location of component(s) on its printed circuit board. LEDs will be used to display module status.

3.3.6 Electrical Isolation

Optical isolators will be used for electrical isolation of digital signals on digital I/O cards. Differential inputs will be available for analog signals.

3.3.7 Mitigation of Static Discharge

The minimization of static sources and discharge will be considered.

3.4 Documentation

The documentation for the Module Level Controller components will support the design of the controller and will contain theory of operation, block diagrams, schematics, information for trouble-shooting at the component level, and testing procedures.

3.5 Characteristics of Auxiliary Elements

3.5.1 Software Support

A well-structured programming environment that supports C and Assembly languages will be available for the processor selected for the Module Level Controller. The operating system/kernel will have multitasking and real-time capabilities. Performance analysis tools will be available to support the controller.

3.5.2 Hardware Support

The Module Level controller shall have emulators and logic analyzers available to facilitate debugging and testing. Controller serialization shall be provided through on—board ROM.

3.5.3 Testing and Verification

Power on self—test will be provided with the Module Level Controller. A test card should be available to test the integrity of the appropriate functional cards . used in the controller. Closed—loop checks will be available to help maintain internal consistency. A LAN monitor shall be available to test and maintain the LAN interface.

3.6 Technology Export License

None of the components of the Module Level Controller will violate current export restrictions.

3.7 Life Cycle Cost Reference Model

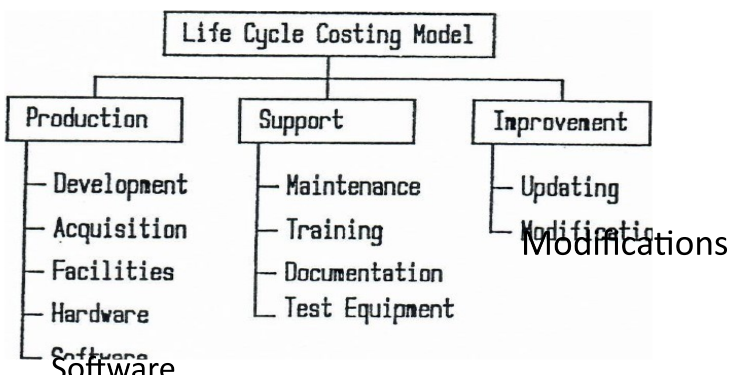


Figure 2. The life cycle costing model will be used in the comparison of alternative design and support approaches.

GLOSSARY

Cluster Controller: A controller that coordinates and controls multiple Module Level Controllers.

CSMA/CD (Carrier Sense Multiple Access with Collision Detect): An IEEE standard (802.3) media access method by which two or more stations share a common bus transmission medium.

IEEE: Institute for Electrical and Electronic Engineers

LAN (Local Area Network): A general=purpose communications network that provides interconnection of a variety of data communications devices within a small area. The devices are typically terminals, microcomputers, and minicomputers.

LCD: Liquid Crystal Display

LED (Light Emitting Diode): A semiconductor diode which emits light when voltage is applied to it.

MESC: Modular Equipment Standards committee

Module Level Controller: A controller that coordinates the operations of a semiconductor processing module.

NVM (Non—volatile Memory): A memory whose stored data is undisturbed by removal of operating power.

Optical Isolation: A method of electrical noise isolation through the use of an optical device.

SCSI (Small Computer Systems Interface): A relatively high-speed parallel I/O interface common to workstations and minicomputers.

SEMI: Semiconductor Equipment Manufacturing Institute

STEP: Safety Training Education Program

TTL: Transistor—Transistor Logic

VGA (Video Graphics Array): A high-resolution video subsystem used for displaying textual/ graphical information on a video terminal .

Virtual Terminal: A simulated terminal interface (typically across a LAN).

Watchdog Timer: A device used to detect whether a processor is executing code in a reasonable sequence.

Workcell Controller: A controller that coordinates the operation(s) of dissimilar objects, e.g. materials handling, stepper motor, Cluster Controller, etc., contained in a single, logical entity known as a workcell.