



BATTERY & CELL TEST EQUIPMENT WORLDWIDE

MACCOR, INC.

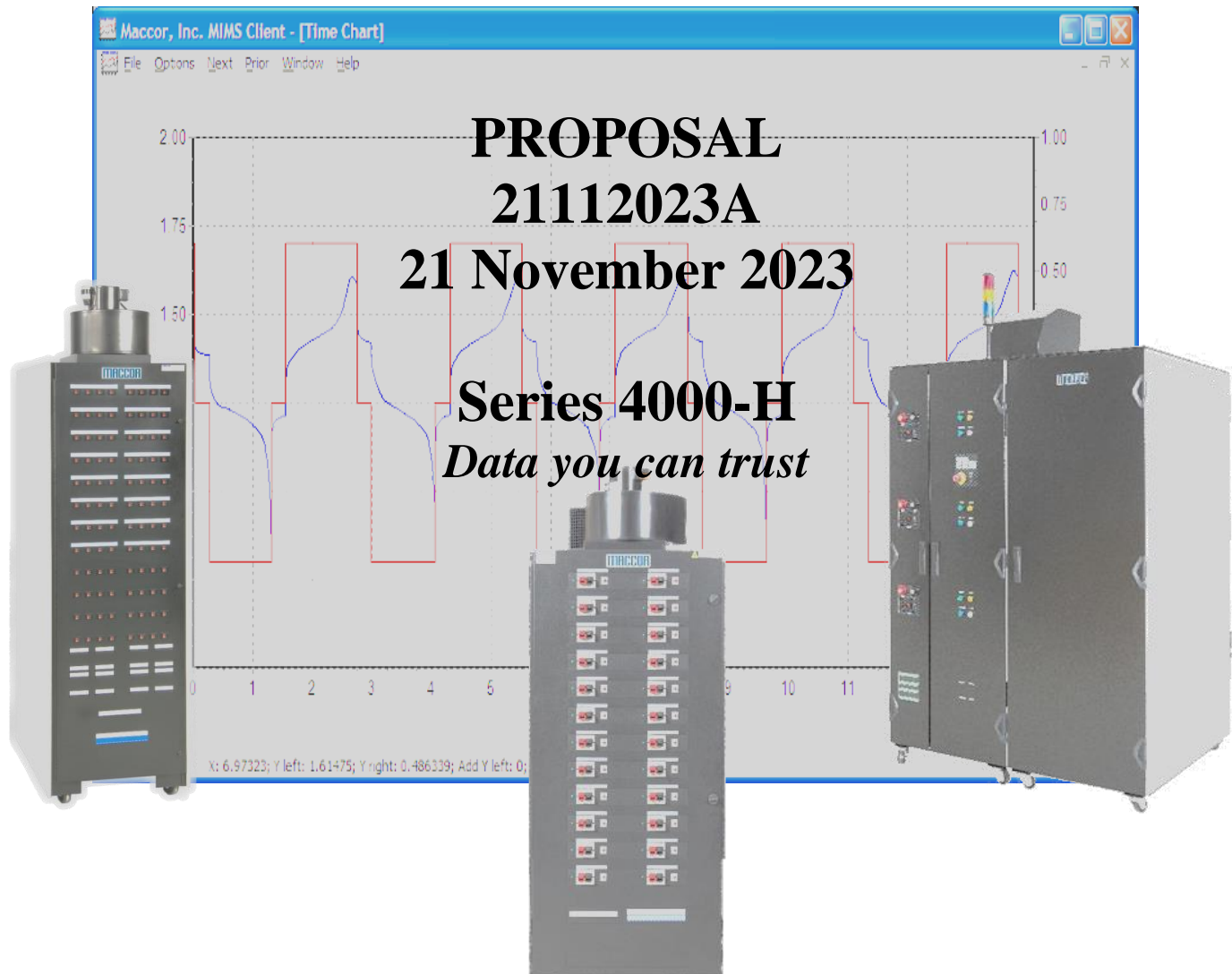
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CONFIDENTIAL INFORMATION



Maccor is founded on the driving belief that putting customer needs above all is crucial to having a successful business. That drive led to the development of the Maccor Standard for our test equipment requiring the following qualities:

- ☒ simple to operate and use
- ☒ long-term support and sustainability
- ☒ high functioning hardware that is improved with software
- ☒ easily scalable
- ☒ it works when you need it to work.

At Maccor, customers come first.

These beliefs become reality with the following actions:

Accuracy and Drift: In order to obtain reliable and dependable data, equipment must accurately control and measure its output. Maccor was the first company to offer test channels with multiple current ranges. Today, Maccor offers the highest accuracy for equipment of this type. Drift is the enemy of accuracy. Economical components will drift with temperature and time. Thus, Maccor utilizes the highest quality components in their designs.

Time Resolution: With a standard 10 mS time resolution, which in some cases is 100 times faster than others, accuracy and safety is improved. Every 10 mS measurements are made and adjusted. In the event of a battery failure, voltage overruns are measured and the channel is shutoff quickly.

Distributed Architecture: The software communicates with multiple controller boards inside the cabinet. When a test is started, the test parameters are downloaded to these controller boards which in turn operate and perform the test. In the unlikely event a channel fails, the failure is limited to the channel, allowing all other channels in the system to continue to operate. Maccor does not allow one component shutdown all your testing.

On-site support: With an extensive customer service team, upgrades, service, and repairs are done on-site. There is no need to ship your entire equipment for service. This greatly reduces downtime and improves performance.

Free and Unlimited Phone and e-mail support: For as long as you own the tester; we are here to help you succeed. Our highly skilled customer service team has over 100 work-years of experience. Support facilities are located all over the world to better serve you.

Backwards Compatible Software: With powerful and very capable hardware, new software versions continue to increase the system's capabilities. Each user can take full advantage of features as they become available. For example, the first Windows-based Maccor tester was delivered in 1995. Today, that system runs the newest released software at no cost from Maccor. Yes, a machine that is nearly three decades old will run software developed today.

No third-party licenses or annual fees: Systems are sold as "turn-key" with everything needed to be up and running quickly. There is no requirement to purchase third-party software to operate a new tester. There is also no annual maintenance or operation fee.



Key Features include:

- Each test channel is controlled independently of the other channels in the system.
- 10 mS control and measurement for increased safety and accuracy.
- Each test step is easily programmed with either fixed or variable outputs.
- Branch to any other step in the test based on the step end criteria met.
- Interface with external control software through the included DLL or UDP portal.
- CAN hardware is available for seamless integration to the tester.
- Real-time viewing of data can be plotted, converted, or printed.
- Comprehensive graphing software is included with each test system. View the data on the tester or on your desktop in real-time.
- Data from multiple test channels may be plotted on a single chart, or multiple charts can be created as a single view.
- When using with an uninterruptible power supply (UPS) data is automatically backed up and channels are safely shutdown in the event of power failure.
- Control environmental chambers from within the test procedure and log their temperature.
- Test systems are delivered calibrated to NIST traceable standards and requiring recalibration only once per year.

Specifications

Number of Channels	*
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Current

Range 1	-15 mA to +15 mA Full Scale $\pm 0.01\%$ FS
Range 2	-150 mA to +150 mA Full Scale $\pm 0.01\%$ FS
Range 3	-1.5 A to +1.5 A Full Scale $\pm 0.01\%$ FS
Range 4	-15 A to +15 A Full Scale $\pm 0.01\%$ FS
Current Control Range (Charge)	+30 μ A to +15 A
Current Control Range (Discharge)	-30 μ A to -15 A

Voltage Measurement Range	0 to +5 Volts Full Scale ± 1 mV
Voltage Accuracy	$\pm 0.02\%$ FS
Maximum Charge Voltage	+5 Volts
Minimum Discharge Voltage	0 Volts
Resolution (voltage and current)	16-bit (1 part in 65,536)

Modes of Operation

Constant Current	Constant Resistance
Constant Voltage	Constant Power
Waveform – allows the streaming of an external text test file (i.e. FUDS drive cycle test) to the test system	
Functions – refer to Appendix C for additional information concerning this feature	
Parallel Channels in blocks of 2, 4, or 8	

Time

Minimum Step Time	10 mS
Control, Measurement, and Adjustment	every 10 mS

System Size and Configuration

Approximate Floor Standing Test Cabinet Dimensions	Width: 90 cm
	Depth: 100 cm deep
	Height: 225 cm high

Battery Interface	Power-Pole Connectors
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Additional Items Supplied

Tester PC

Software/License

Maccor's 32-bit Windows based battery test software

MIMS Client graphical and statistical software

MIMS Server Software for automatically transferring data

Software license includes lifetime updates at no additional cost. This license is not transferrable in the event the system is given away, donated, or sold.

2200VA True On-Line Uninterruptible Power Supply

On-site Commissioning and training

A Maccor representative would arrive on-site at a mutually agreed time after the system arrives and is installed by the customer. The system will be verified to ensure it is functioning properly after shipment.

Pricing

Net Price - 48 Channels (ex-works)

US\$127,900

Net Price - 96 Channels (ex-works)

US\$201,200

Terms and Shipment

Payment Terms:

40% paid with order,
40% paid prior to shipment,
20% net 30 days from date of shipment

Shipment:

135 days from receipt of order and initial payment

Validity:

60 days

Warranty:

12 months from date of shipment for parts and labor
when the equipment is used for intended purposes.

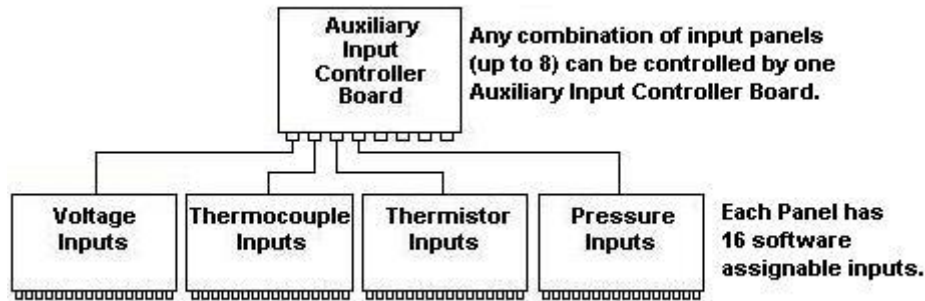
Notes:

1. In the event of contract cancellation after receipt of order, all amounts received by Maccor will be retained as partial compensation for labor and materials expended.
2. Only those items and services described above shall be provided. All other items or services not specifically mentioned shall be the responsibility of the addressee of this proposal.
3. Pricing is based on the information submitted to Maccor. Should actual conditions or details be different, additional costs may be incurred by the addressee of this proposal.
4. Maccor retains the title to all goods, including parts and equipment, until full payment is made by the purchaser.

Options

Auxiliary Inputs (Options 1 – 6)

Voltage, thermocouple, thermistor, and pressure input panels can be added to the system with the addition of an Auxiliary Input Controller Board. Any combination of input panels, up to eight (8), can be specified per Auxiliary Input Controller.



Each input panel type, whether voltage, thermocouple, thermistor, or pressure has sixteen (16) inputs and are specified as a single type. For example, when specifying a Thermocouple Input Panel all inputs must be of the same type (K, T, or J) or when specifying a voltage input panel all inputs for that panel must be the same (e.g., ± 5 volt, ± 10 volts, etc.).

All inputs are software assignable to any test channel and one any combination of inputs can be assigned to any test channel. Data from the inputs becomes a permanent part of the data file for the channel assigned, and test flow can be controlled by the inputs.

1. Auxiliary Input Controller Board

Auxiliary Input Controller Boards allow for the addition in any combination of up to eight (8) Input panels (see below). Systems may have multiple Auxiliary Controller Boards installed.

Complete price for an Auxiliary Input Controller Board including all hardware and software modifications to the test system, is \$4,810.

2. Reference (Auxiliary) Voltage Inputs

Voltage Inputs can be added to the system in blocks of sixteen (16) and are assignable to any test channel. The voltage inputs are high impedance fully isolated and can be specified with various ranges such as: ± 5 volts, ± 10 volts, etc). Any combination of voltage inputs can be assigned to a test channel, and data measured by these inputs becomes part of the data record for the test channel assigned.

Voltages measured by these inputs can control operation of the test channel assigned, display real time values, or plotted either as a single input or overlay all the inputs associated with the test.

Complete price including all hardware and software modifications to the test system, is \$4,870 for each block of sixteen.

3. Isolated Thermocouple Inputs (sensors not included)

Thermocouple Inputs can be added to the system in blocks of sixteen (16) and are assignable to any test channel. With the Thermocouple inputs assigned to a channel a historical record of temperature can be obtained. Temperature functions can be used to control tests performed on channels with thermocouple inputs on the basis of absolute temperature, $\Delta T/\delta t$, ΔT , and several others. Type K, T, or J are available.

Complete price including all hardware and software modifications to the test system, is \$5,520 for each block of sixteen.

4. RTD Inputs (RTD sensors not included)

RTD Inputs can be added to the system in blocks of sixteen (16) and are assignable to any test channel. With the RTD inputs assigned to a channel a historical record of temperature can be obtained. Temperature functions can be used to control tests performed on channels with RTD inputs on the basis of absolute temperature, $\Delta T/\delta t$, ΔT , and several others.

Complete price including all hardware and software modifications to the test system, is \$7,030 for each block of sixteen.

5. Thermistor Inputs

Thermistor Inputs can be added to the system in blocks of sixteen (16) and assigned to any test channel. Thermistor inputs provide similar capability as the Thermocouple inputs described above.

Complete price including all hardware and software modifications to the test system, is \$7,030 for each block of sixteen.

6. Pressure (Strain Gauge) Inputs

Pressure Inputs can be added to the system in blocks of sixteen (16) and are assignable to any test channel. With the pressure inputs, a historical record of pressure is stored in the data file for the channel's which have these inputs assigned. Data obtained from the inputs can be used to control a test channel based on absolute pressure, $\Delta P/\delta t$, ΔP , and several others.

Complete price including all hardware and software modifications to the test system, is \$5,520 for each block of sixteen.

7. Cables

Cables are Four-wire, terminated with power pole connectors for tester interface and ring lugs for user interface

3 meters	Pricing Available Upon Request
5 meters	Pricing Available Upon Request

8. SMB Battery Interface

The SMB battery interface allows for the reading of data from battery packs fitted with SMB electronics. The data read from the battery becomes a permanent part of the data file's record. Comparisons between measured values and data from the pack can be made. The module has twelve (12) positions. Maccor must receive at least 2 SMB packs for evaluation to determine compatibility with test system. If more than 1 model of pack is to be tested, Maccor will require 2 SMB packs for each different model. Please see Appendix A – SMB OPTION for more information concerning this feature.

Complete price including all hardware and software modifications to the test system, is \$9,705 per group of twelve channels.

9. Digital Inputs

Allows for the Reading of TTL based logical inputs. Allows you to mask bits, read high-low of each bit to control the flow of the test procedure. Please see Appendix B for details.

Complete price including all hardware and software modifications to the test system, is \$4,010 per group of 32 bits. This option requires an auxiliary input controller board (option #1).

10. Digital Outputs

Allows you to set one or all bits high or low. May be used to trigger an event or simply display status lights. Please see Appendix B for details.

Complete price including all hardware and software modifications to the test system, is \$4,010 per group of 32 bits. This option requires an auxiliary input controller board (option #1).

11. External Charge Controller or External Load Controller

External Charge Controllers can be added to any or all of the test channels. These devices work as follows: The test channel retains all of the capabilities it normally has. In addition, tests run on the channel can connect to an external charger during a particular step. During such connection, all the data gathering capabilities and all the step end conditions of the test channel can still be used.

External Load Controllers can be added to any or all of the test channels. These devices work as follows: The test channel retains all of the capabilities it normally has. In addition, tests run on the channel can connect to an external load during a particular step. During such connection, all the data gathering capabilities and all the step end conditions of the test channel can still be used.

For any mixture of external charger or load controllers, price is \$3,650 plus \$1,095 for each 10 amp rated controller, \$2,640 for each 50 amp rated controller, or \$5,010 for each 200 amp rated controller per test channel.

12. CAN (Controller Area Network) Communications

Test system would be capable of receiving CAN communications from the battery modules and storing the data in the data file. The details of the specifications for the CAN communications will be by mutual agreement.

Complete price including all hardware and software modifications to the test system, is \$3,975 per channel.

13. Cell Holders

Molded True 4-Wire Kelvin Cell Holders

AAA	\$80 each
AA	\$80 each
C	\$84 each
D	\$88 each
18650	\$91 each
21700	\$93 each
PLI	\$158 each
Coin Cell – Size 2032	\$76 each
Universal button cell holders	\$275 each
8 Position Adjustable Cylindrical Cell Holders	\$2,660 each

14. Cell Balancer

The Maccor Cell Balancer is a device which is able to charge and discharge individual cells within a battery pack simultaneously. A single cell balancer supports a maximum of 8 cells. Multiple cell balancers can be used in series in order to balance a battery pack with more than 8 cells. The cell balancers are configured for 0V to +5V with a maximum current of 1000mA.

8-cell Balancer.....	\$5,715
16-cell Balancer.....	\$11,430
24-cell Balancer.....	\$17,145
32-cell Balancer.....	\$22,860
40-cell Balancer.....	\$28,575
48-cell Balancer.....	\$34,290



Note: the cell balancer is supplied in an enclosure separate from the test system. The cell balancer must be placed near the battery pack to minimize the length of the interface cable.

15. Temperature Chamber

Approximately 1 ft³ of workable area and the ability to be stacked in a 19" rack mount cabinet (optional). Chambers are available in a heat/cool configuration with features and specifications as follows:

Features include:

Addressable Chamber Controllers: allows integration of up to 32 chambers into a single test system.

Automatic Temperature Control: allows chamber temperature to be set directly from Maccor's test system software as a test step in the test procedure.

Compact Design: with a height of only 12.25" (7U High), stacking chambers on a table or installation into a standard 19" rack cabinet easy.

Specifications:

Cooling\Heating Power	250 Watts (850 BTU/Hour)
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Temperature Range:	
Heat/Cool	-20°C to 100°C

Temperature Uniformity	±0.5°C
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Temperature Accuracy	±0.5°C
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AC Input	220VAC/1 Φ/15 Amps
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Unit Dimensions	18.5" Wide x 30" Deep x 12.25" High
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Pricing:

Heat/Cool	US\$13,165 each
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Options:

19" rack cabinet (can handle up to 4 chambers):	US\$5,065 each
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16. Combining Channels

Allows similarly rated channels to be combined in parallel in groups of 2, 4 or 8 for increased current.

Complete price including all hardware and software modifications to the test system, is \$5,830.

APPENDIX A – SMB OPTION

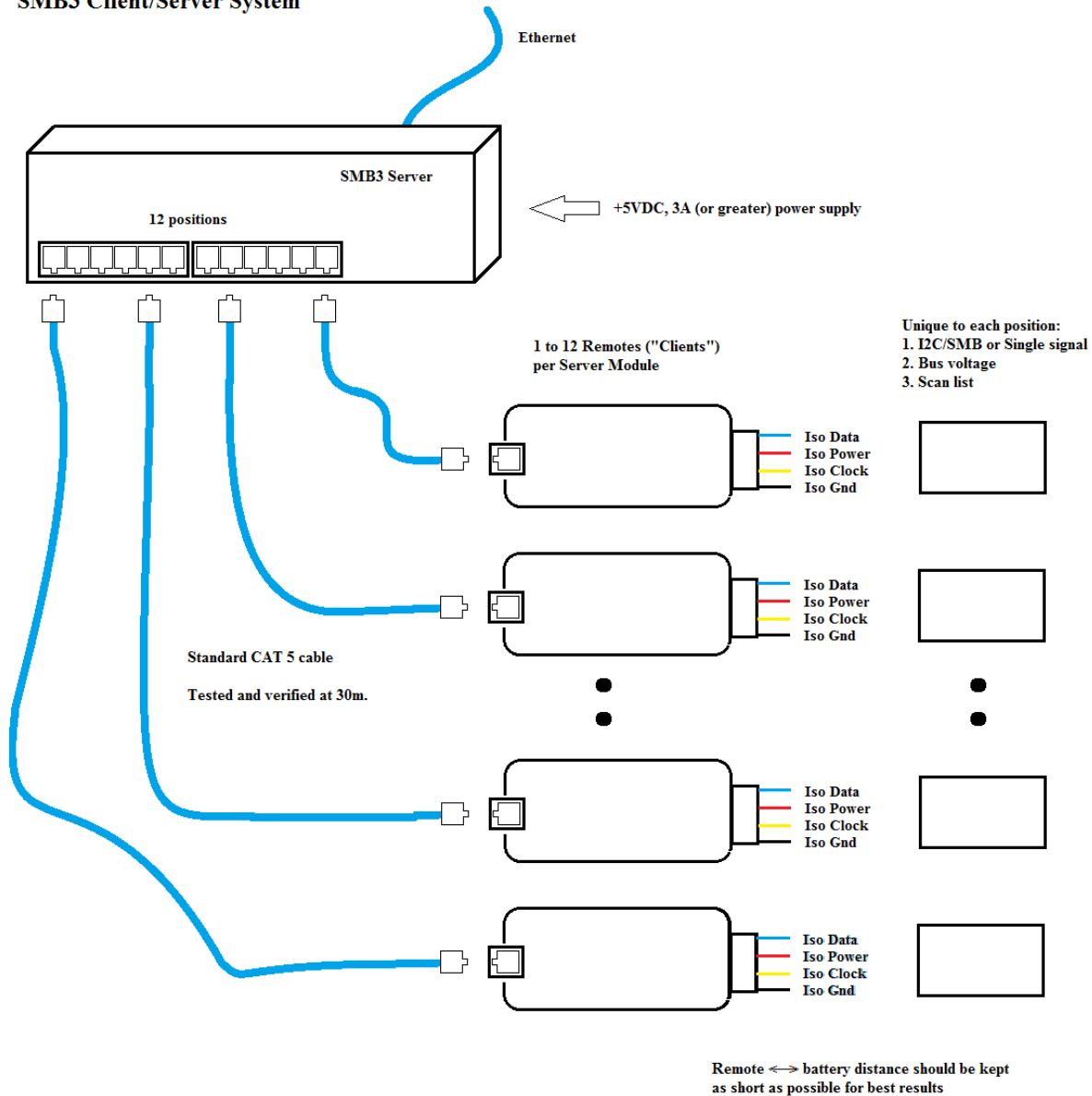
SMB3 is the latest version of Maccor's SMBus communications interface for use in evaluating Smart Battery Packs in conjunction with the Maccor range of battery test systems.

Maccor's SMB3 feature allows the System Management Bus (SMB) to communicate with an active smart battery pack. The system is capable of interrogating the smart battery pack to read the data from the pack and respond to the following SMB alarms: Over-Charge-Alarm, Terminate-Charge-Alarm, Over-Temperature-Alarm, and Terminate-Discharge-Alarm. All steps ending due to a Smart Battery alarm displays an ES code of 35 in the ES column of the data file. The data from the Smart Battery pack consists of Header Information and Data Information. The data information read from the Smart Battery pack can be viewed in real time from the detailed screen for the test channel the pack is assigned to. The header information and all data information can be viewed from the data file.

Additional Features for SMB3:

- Operates with both the new single-wire and conventional two-wire SMBus communication systems, as well as with I²C and HDQ.
- Dedicated processor per position; provides higher speed and allows each SMB position to be completely independent, with a different Bus type, Bus voltage, Clock Frequency, and different set of Fields (Scan list).
- SMB/ I²C clock is adjustable up to 100 KHz
- Bus voltage is variable from 0.9V to 4.8V
- Implementation of a remote (client) module for each SMB position allows the distance from the Smart Battery Pack to the Maccor test cabinet to be greatly extended up to 30m.
- Approximately 10 X Faster device data update rate to the test channel, as fast as every 2 seconds total for all fields in all 12 positions.
- Can read 1 or 2 bytes, or a string of up to 20 bytes.
- Optional Temperature Sensor local to the pack under test, to display the ambient pack temperature.
- Individual electrical isolation between positions >300V.
- Can replace existing Maccor SMB1 systems or can be used in conjunction with existing Maccor SMB1 systems.
- Uses standard RJ45 connectors for test cabinet interface to provide more flexibility with interconnections.

SMB3 Client/Server System



Schematic Diagram of SMB3

- The 12 position Server Module is normally installed in the Maccor test system cabinet, and can be located up to 30 m distance from the Remote Client Module, using a standard CAT5 Ethernet cable.
- The Remote Client Module must be located no more than 0.3 m from the Smart Battery under test, to ensure reliable communication.

Setup Smart Battery

Channel Assignment SB Position Setup SB Module SB Position

SB Module	SB Pos.	Test Channel
1	1	1
1	2	2
1	3	3
1	4	4
1	5	5
1	6	6
1	7	7
1	8	8
1	9	In use (9)
1	10	In use (10)
1	11	In use (11)
1	12	In use (12)

Position Header

Address	Bytes	Type	Error val	Designator	Format
0x01	2	Word	0xFFFF	RemainingCapacityAlarm	Unsigned
0x02	2	Word	0xFFFF	RemainingTimeAlarm	Unsigned
0x03	2	Word	0xFFFF	BatteryMode	Binary
0x04	2	Word	0xFFFF	AtRate	Unsigned
0x05	2	Word	0xFFFF	AtRateTimeToFull	Unsigned
0x06	2	Word	0xFFFF	AtRate	Unsigned
0x07	2	Word	0xFFFF	AtRateTimeToEmpty	Unsigned
0x08	2	Word	0xFFFF	AtRate	Unsigned
0x09	2	Word	0xFFFF	AtRateOK	Unsigned
0x0A	2	Word	0xFFFF	Temperature	Celsius
0x0B	2	Word	0xFFFF	Voltage	Float2UD 1000
0x0C	2	Word	0xFFFF	Current	Float2SD 1000
0x0D	2	Word	0xFFFF	AverageCurrent	Float2SD 1000

Bus type: Clock Freq. Divisor: Bus/Logic V:

Device addr: Access delay (ms):

Save Assignment Add Move Up Copy from Save Position

Insert Move Down Std. setup

Delete

Close

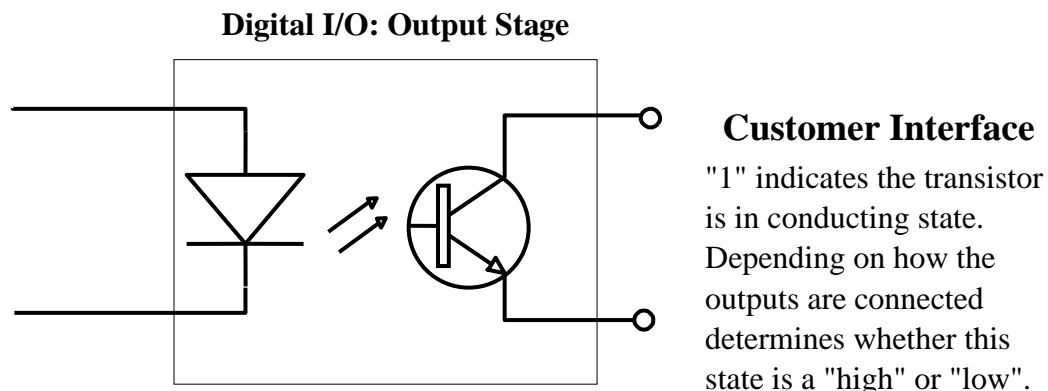
Example of Setup

- Allows each Smart Battery position to be independently set up with its own parameters including Address, No. of Bytes, Type, Designator (name of measured value), Bus type, Bus/Logic voltage, and how fast you want to read each data field (from 1mS to 250mS).

APPENDIX B – DIGITAL I/O OPTION

The Digital I/O hardware is TTL based, optically isolated inputs or outputs. The loading and power supply to drive the load are the responsibility of the customer. The inputs are based on +5V but can be customized if necessary. The outputs can handle 100mW of power and are rated at 300V/150mA.

The following is a brief description of the operation of the Digital I/O feature that is available on Maccor Series 4000 Battery Test Systems: **I/O Out:** entered in the type column, this step outputs the 7 bit binary pattern entered in the **Val** column (e.g. X0110110) to the associated channel port. This bit pattern is held on the outputs until another I/O Out command is programmed to the port. The capabilities of the Digital I/O features include both procedure flow control and variable state bit data. This pattern produces 7 bits, consisting of ones, zeros, or X's. An X represents a “don't care” state. **I/O In:** entered in the End Type column, this step reads the bit pattern present at the associated channel port and compares it to the 7 bit binary pattern entered in the **Val** column (e.g. 011X110X). The step ends when the bit pattern on the associated channel port matches the 7 bit pattern entered in the **Val** column. This feature also uses a pattern of 7 bits consisting of ones, zeros, or X's with the X's representing a “don't care” state. The “don't care” state means that for inputs that particular input is not used for comparison and for outputs the output is not used or remains unchanged for that step.



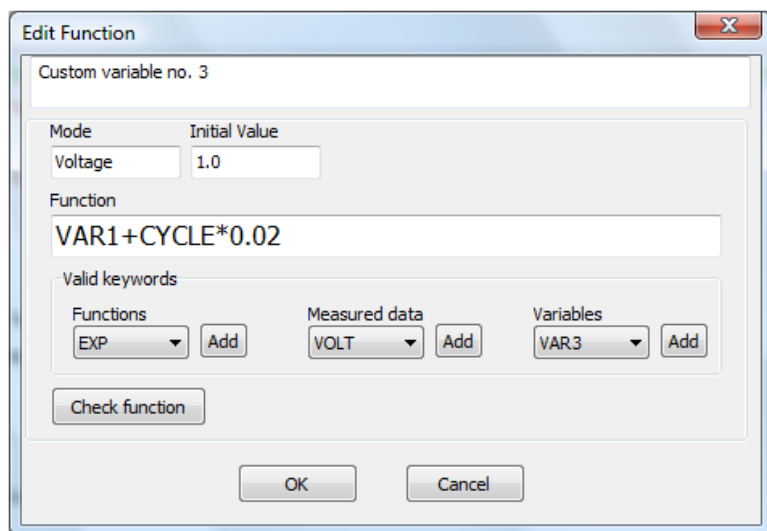
The digital inputs and/or digital outputs are software assignable to the test channel(s). The maximum number of digital inputs or digital outputs assigned to a single test channel is (7 bits for inputs and 7 bits for outputs). However, it is possible to have a digital input and digital output assigned to the same test channel. The digital input(s) and digital output(s) do have separate interface connectors. The digital input and digital output boards have 32 bits per board.

APPENDIX C – FUNCTIONS

The functions feature in the MacTest32 software operate as follows:

Mostly it is accessible from Build Test, and the functions are entered in three places:

Set points: Two new steps types are introduced: ChgFunc and DisFunc. These steps work largely as regular charge and discharge steps except that the value and limits are functions. When you click on the value fields this dialog will come up:



The function is entered in the function field, and valid mathematical functions, measured values and custom values are selected and added from the valid key words. The syntax is checked before it can be accepted. The example will generate a voltage staircase when it is in a loop. This is also known as PITT: Potentiostatic Intermittent Titration Technique.

When the step is running the channel voltage setpoint will be set according to this function up to ten times per second depending on how busy the system is.

Ends: A new end type called "Function" is added and when the value cell is clicked the same dialog comes up. However, the function must now be a Boolean expression, and when this expression is met, the step will terminate and jump to the step# in the goto field. Multiple function steps are allowed in the same step keeping the processing time in mind.

Reports: A new report type called "Set Variable" is introduced. It doesn't cause a normal report (i.e. a data point) Instead it sets a variable. Clicking the value brings up this dialog (same as before with some differences):

In this example it will set the variable called "VAR1" to the voltage reading at the end of the step, but it can be any function of the available data and other variables.

The available measurements are:

VOLT	AUXV
CURRENT	AUXT
CAPACITY	AUXTR
ENERGY	AUXP
TTIME	AUXR
STIME	STEP
SMB0X	CYCLE
ACIMP	

The available variables are:

CRATE	AREA
VRATE	VAR1
PRATE	VAR2
RRATE	VAR3
MASS	VAR4
VOLUME	

The C-rate is the one that can be entered at test start with the plan to make the other available at test start as well.