Sorensen

MML SERIES

Operation and Programming Manual

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CONDITIONS OF WARRANTY

- To return a defective product, contact a Sorensen representative or the Sorensen factory for an RMA number. Unauthorized returns will not be accepted and will be returned at the shipper's expense.
- For Sorensen products found to be defective within thirty days of receipt by the original purchaser, Sorensen will absorb all ground freight charges for the repair. Products found defective within the warranty period, but beyond the initial thirty-day period, should be returned prepaid to Sorensen for repair. Sorensen will repair the unit and return it by ground freight pre-paid.
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- Warranty field service is available on an emergency basis. Travel expenses (travel time, per diem expense, and related air fare) are the responsibility of the Buyer. A Buyer purchase order is required by Sorensen prior to scheduling.
- A returned product found, upon inspection by Sorensen, to be in specification is subject to an inspection fee and applicable freight charges.
- Equipment purchased in the United States carries only a United States warranty for which repair must be accomplished at the Sorensen factory.

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SAFETY NOTICE

Before applying power to the system, verify that the MML Series unit is configured properly for the user's particular application.

WARNING!

HAZARDOUS VOLTAGES IN EXCESS OF 280 VRMS, 600V PEAK MAY BE PRESENT WHEN COVERS ARE REMOVED. QUALIFIED PERSONNEL MUST USE EXTREME CAUTION WHEN SERVICING THIS EQUIPMENT. CIRCUIT BOARDS, TEST POINTS, AND OUTPUT VOLTAGES MAY BE FLOATING ABOVE (BELOW) CHASSIS GROUND.

Installation and service must be performed by qualified personnel who are aware of dealing with attendant hazards. This includes such simple tasks as fuse verification.

Ensure that the AC power line ground is connected properly to the MML Series unit input connector or chassis. Similarly, other power ground lines including those to application and maintenance equipment must be grounded properly for both personnel and equipment safety.

Always ensure that facility AC input power is de-energized prior to connecting or disconnecting the input/output power cables.

During normal operation, the operator does not have access to hazardous voltages within the chassis. However, depending on the user's application configuration, HIGH VOLTAGES HAZARDOUS TO HUMAN SAFETY may be generated normally on the output terminals. Ensure that the output power lines are labeled properly as to the safety hazards and that any inadvertent contact with hazardous voltages is eliminated. To guard against risk of electrical shock during open cover checks, do not touch any portion of the electrical circuits. Even when the power is off, capacitors can retain an electrical charge. Use safety glasses during open cover checks to avoid personal injury by any sudden failure of a component.

Due to filtering, the unit has high leakage current to the chassis. Therefore, it is essential to operate this unit with a safety ground.

Some circuits are live even with the front panel switch turned off. Service, fuse verification, and connection of wiring to the chassis must be accomplished at least five minutes after power has been removed via external means; all circuits and/or terminals to be touched must be safety grounded to the chassis.

After the unit has been operating for some time, the metal near the rear of the unit may be hot enough to cause injury. Let the unit cool before handling.

Qualified service personnel need to be aware that some heat sinks are not at ground, but at high potential.

These operating instructions form an integral part of the equipment and must be available to the operating personnel at all times. All the safety instructions and advice notes are to be followed.

Neither Sorensen, San Diego, California, USA, nor any of the subsidiary sales organizations, can accept any responsibility for personal, material or consequential injury, loss, or damage that results from improper use of the equipment and accessories.

SAFETY SYMBOLS

CAUTION
Risk of Electrical Shock

CAUTION
Refer to Accompanying Documents

Off (Supply)

Standby (Supply)

On (Supply)

Protective Conductor Terminal

Direct Current (DC)

Alternating Current (AC)

3~ Three–Phase Alternating Current

Fuse

Earth (Ground) Terminal

CONTENTS

1. GENERAL INFORMATION

1.1 Introduction 1-1
1.2 Description 1-1
1.3 Overview of Key Features 1-1
1.4 Specifications 1-2

2. INSTALLATION

2.1 Introduction 2-1
2.2 Inspection 2-1
2.3 Installing the Modules 2-1
2.3.1 Channel Number 2-2
2.4 Installing the Mainframe 2-3
2.4.1 Changing Line Voltage 2-3
2.4.2 Turn-On Self-Test 2-4
2.5 Application Connection 2-5
2.5.1 Load Connections 2-5
2.5.2 Remote Sensing Connections 2-6
2.5.3 Parallel Connections 2-7
2.6 Remote Control Connection 2-7

3. OPERATION OVERVIEW

3.1 Introduction 3-1
3.2 Front Panel Description 3-1
3.3 Rear Panel Description 3-2
3.4 Local/Remote Control 3-2
3.5 Modes of Operation 3-3
3.5.1 Constant Current Mode 3-3
3.5.2 Constant Resistance Mode 3-6
3.5.3 Constant Voltage Mode 3-7
3.6 Load Synchronization 3-8
3.7 Measurements 3-8
3.8 Slew Rate and Minimum Transient Time 3-8
3.9 Start/Stop Sink Current 3-8
3.10 Short On/Off 3-10
3.11 Load On/Off 3-10

3.12 Protection Features 3-10
3.13 Save/Recall Setting 3-12
3.14 Program..3-12

4. LOCAL OPERATION

4.1 Introduction..4-1
4.2 Local Operation of Load Mainframe 4-1
4.1.1 Selecting the Channel 4-3
4.1.2 Setting the Operation Mode...4-3
4.1.3 Setting the Program...4-7
4.1.4 Running the Program 4-10
4.1.5 Setting the Specifications 4-10
4.1.6 Setting the Configuration 4-11
4.1.7 Recalling Files 4-15
4.1.8 Saving Files...4-15
4.1.9 Saving Defaults 4-16
4.1.10 Saving Programs..4-16
4.1.11 Going To Local 4-16
4.1.12 Lock Operation 4-16
4.1.13 Setting System and RS-232C Connection....................................4-16
4.1.14 Connecting the GO/NG Output Port 4-17
4.1.15 Setting the GPIB Address...4-17
4.3 Local Operation of Load Module 4-18
4.3.1 Local Operation of Single Channel/Module (Panel A) 4-18
4.1.2 Local Operation of Double Channels/Module (Panel B) 4-21
4.1.3 Online Change Level 4-24

5. REMOTE OPERATION

5.1 Introduction..5-1
5.2 DIP Switches on the GPIB Card...5-1
5.2.1 GPIB Address...5-1
5.2.2 Other DIP Switches 5-2
5.3 GPIB Capability of the Electronic Load...5-3
5.4 RS232C in Remote Control...5-3
5.5 Basic Programming Definitions 5-4
5.6 Numerical Data Formats...5-5
5.7 Character Data Formats 5-6

5.8 Separators and Terminators 5-6
5.9 Language Dictionary 5-8
5.9.1 Common Commands 5-8
5.10 Specific Commands 5-13
5.10.1 ABORT Subsystem 5-13
5.10.2 CHANNEL Subsystem 5-13
5.10.3 CONFIGURE Subsystem 5-16
5.10.4 CURRENT Subsystem 5-21
5.10.5 FETCH Subsystem 5-25
5.10.6 LOAD Subsystem 5-27
5.10.7 MEASURE Subsystem 5-29
5.10.8 MODE Subsystem 5-32
5.10.9 PROGRAM Subsystem 5-33
5.10.10 RESISTANCE Subsystem 5-37
5.10.11 RUN Subsystem 5-39
5.10.12 SHOW Subsystem 5-39
5.10.13 SPECIFICATION Subsystem 5-40
5.10.14 STATUS Subsystem 5-43
5.10.15 VOLTAGE Subsystem 5-48
5.11 Status Reporting 5-50
5.11.1 Introduction 5-50
5.11.2 Register Information in Common 5-50
5.11.3 Channel Status 5-52
5.11.4 Channel Summary 5-53
5.11.5 Questionable Status 5-53
5.11.6 Output Queue 5-54
5.11.7 Standard Event Status 5-54
5.11.8 Status Byte Register 5-55
5.11.9 Service Request Enable Register 5-55

6. PROGRAMMING EXAMPLE

Table of Contents

7. CALIBRATION PROCEDURES 7-1

7.1 Introduction 7-1

7.2 Test & Calibration Setup Configurations 7.2

7.3 Required Test Equipment 7.3

7.4 Calibration Procedures of MML-80-20-102 .... 7.4

7.5 Calibration Procedures of MML-80-60-301 7-7

7.6 Calibration Procedures of MML-500-10-301 7-9

7.7 Calibration Procedures of MML-80-120-601 7-16

7.8 Calibration Procedures of MML-500-20-601 7-23

7.9 Removing Load Modules 7-31

1 GENERAL INFORMATION

1.1 Introduction

This manual contains specifications, installation, operation, and programming instructions of MML-4, MML-2 electronic load mainframes as well as the MML-80-20-102 and MML-80-60-301 electronic load modules. Here “Load” means the electronic load modules of Sorensen MML series while “Mainframe” the MML-4, MML-2 electronic load mainframes.

1.2 Description

The functions of MML-4 and MML-2 mainframes are the same. The former has four slots for Load modules while the latter two slots. The functions of MML-80-20-102, MML-80-60-301, etc. are all the same. The differences are in input voltage, load current, and power ratings. An individual module may have one or two channels. Each channel has its own channel number, load and measurement connectors, and operates independently in constant current (CC) mode, constant resistance (CR) mode, or constant voltage (CV) mode.

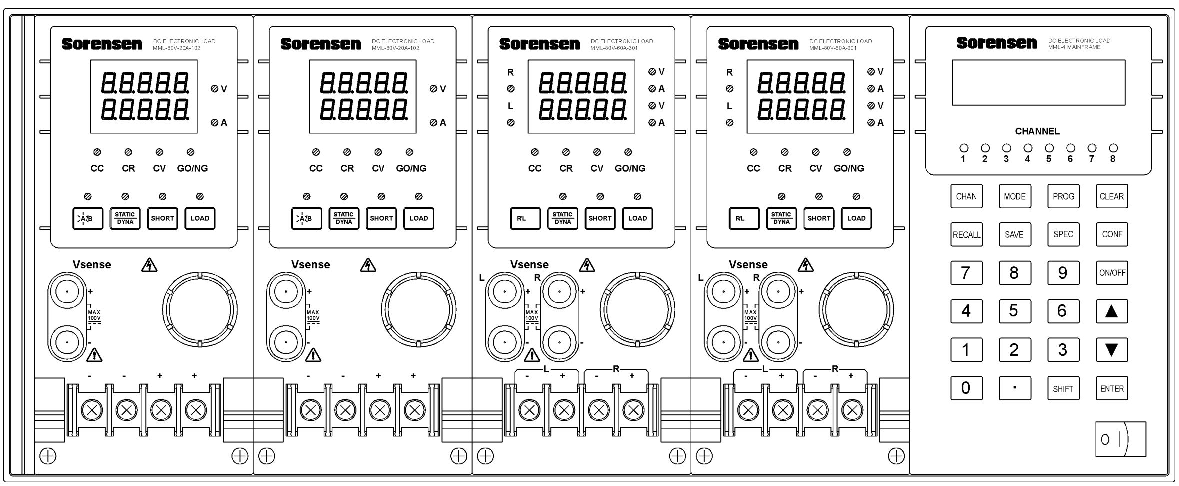


Figure 1-1 Front Panel of the Electronic Load

There are two groups of keypads on the front panel of the electronic load (see Figure 1-1). One is the Mainframe keypad; the other is the Load keypad. In this manual, the Mainframe keypad is referred to as MODE; the Load keypad is referred to as SHORT.

1.3 Overview of Key Features

1.3.1 Configuration

- Flexible configuration using plug-in electronic load modules to mainframes.
- Local operation on front panel keypad.
- Remote control via GPIB or RS-232C interface.
- Photocoupler isolation to offer true floating Load.

- Automatic fan speed control to reduce noise.
- Up to 8 channels for one Mainframe.

1.3.2 Load

- Constant current (CC), constant resistance (CR), and constant voltage (CV) operation modes.
- Programmable slew rate, load levels, load periods, and conduct voltage (Von).
- Programmable dynamic loading with speed up to 20KHz.
- Minimum input resistance allowing load to sink high current even with low input voltage (1 V).
- Selective voltage and current ranges.
- Remote sensing capability.
- 100 sets of memories to save/recall user-definable setups.
- 10 sets of programs to link files for automatic test.
- 15-bit A/D converter with precision measurement.
- Short circuit simulation.
- Automatic GO/NG inspection to confirm UUT within spec.
- Independent GO/NG signals for each channel.

1.4 Specifications★

Mainframe:	MML-4
AC input:	115/230 switchable or 100/200 switchable Vac line
Fuse:	5A/250V
Amplitude:	±10%
Frequency:	47 to 63 Hz
Maximum VA:	180VA
Trigger output:	Vlo = 0.8V maximum at Ilo = 1 mA
	Vhi = 3.2V minimum at Ihi = –40µA
Weight:	24Kg
Dimensions:	Width: 440mm
	Height: 177.4 mm (excluding feet), 186mm (including feet)
	Depth: 560mm (including Load module)

★ Load specifications are listed in the tables below.

NOTES

1. All specifications are tested at 20°C ~ 30°C except otherwise stated.
2. The range of operation temperature is 0°C ~ 40°C.
3. The specifications of DC current accuracy are tested after the input is applied for 30 seconds.
4. The power of the load module of MML series is supplied from MML-4/MML-2 mainframe.
5. The typical temperature coefficient is 100ppm.

MODEL MML-80-20-102(100W*2)		
POWER	20W	100W
CURRENT	0~2A	0~20A
VOLTAGE	1~80V	
MINIMUM OPERATING VOLTAGE (DC)	1.0V at 2A	1.0V at 20A
CONSTANT CURRENT MODE Range	0~2A	0~20A
Resolution	0.5mA	5mA
Accuracy	0.1%+0.1%F.S.	0.1%+0.2%F.S.
CONSTANT RESISTANCE MODE Range	CRL: (0.075Ω~300Ω) (100W/16V) CRH: (3.75Ω~15KΩ) (100W/80V)	
Resolution	12 bits	
Accuracy	CRL: 0.1mho+0.2% CRH: 0.01mho+0.1%	
CONSTANT VOLTAGE MODE Range	1~80V	
Resolution	20mV	
Accuracy	0.05%+0.1%F.S.	
DYNAMIC MODE		
DYNAMIC MODE	C.C. MODE	
T1 and T2	0.025mS~10mS / Res: 1μS 1mS~30S / Res: 1mS	
Accuracy	1μS /1mS+100ppm	
Slew Rate	0.32~80mA/μS	3.2~800mA/μS
Resolution	0.32mA/μS	3.2mA/μS
Current	0~2A	0~20A
Resolution	0.5mA	5mA
Current Accuracy	0.4% F.S.	
MEASUREMENT SECTION		
VOLTAGE READ BACK		
Range	0~16V	0~80V
Resolution	0.5mV	2.5mV
Accuracy	0.05%+0.05% F.S.	
CURRENT READ BACK		
Range	0~2A	0~20A
Resolution	0.0625mA	0.625mA
Accuracy	± (0.1%+0.1% F.S.)	
PROTECTIVE SECTION		
Over Power Protection	≒ 20.8W	≒ 104W
Over Current Protection	≒ 2.04A	≒ 20.4A
Over Temperature Protection	≒ 85°C	
Over Voltage Protection	≒ 81.6V/16.3V	
GENERAL		
SHORT CIRCUIT		
Current (CC)	≒ 2.2/2A	≒ 22/20A
Voltage (CV)	0V	0V
Resistance (CR)	≒ 3.75Ω	≒ 0.075Ω
INPUT RESISTANCE (LOAD OFF)	100KΩ (Typical)	
SIZE	81(W)× 172(H)×495(D)	
WEIGHT (Approx.)	4.2Kg	
EMC and SAFETY	CE	

MODEL MML-80-60-301		
POWER	30W	300W
CURRENT	0~6A	0~60A
VOLTAGE	1~80V	
MINIMUM OPERATING VOLTAGE (DC)	1.0V at 6A	1.0V at 60A
CONSTANT CURRENT MODE Range	0~6A	0~60A
Resolution	1.5mA	15mA
Accuracy	0.1%+0.1%F.S.	0.1%+0.2%F.S.
CONSTANT RESISTANCE MODE Range	0.025Ω~100Ω (300W/16V) 1.25Ω~5KΩ (300W/80V)	
Resolution	12 bits	
Accuracy	CRL (100Ω): 0.1mho+0.2% CRH (5KΩ): 0.01mho+0.1%	
CONSTANT VOLTAGE MODE Range	2.5~500V	
Resolution	20mV	
Accuracy	0.05%+0.1%F.S.	
DYNAMIC MODE		
DYNAMIC MODE	C.C. MODE	
T1 and T2	0.025mS~10mS / Res: 1µS 1mS~30S / Res: 1mS	
Accuracy	1µS /1mS+100ppm	
Slew Rate	0.001~0.25A/µS	0.01~2.5A/µS
Resolution	0.001A/µS	0.01A/µS
Current	0~6A	0~60A
Resolution	1.5mA	15mA
Current Accuracy	0.4% F.S.	
MEASUREMENT SECTION		
VOLTAGE READ BACK		
Range	0~16V	0~80V
Resolution	0.5mV	2.5mV
Accuracy	0.05%+0.05% F.S.	
CURRENT READ BACK		
Range	0~6A	0~60A
Resolution	0.1875mA	1.875mA
Accuracy	± (0.1%+0.1% F.S.)	
PROTECTIVE SECTION		
Over Power Protection	≒ 31.2W	≒ 312W
Over Current Protection	≒ 6.12A	≒ 61.2A
Over Temperature Protection	≒ 85°C	
Over Voltage Protection	≒ 81.6V/16.3V	
GENERAL		
SHORT CIRCUIT		
Current (CC)	≒ 6.6/6A	≒ 66/60A
Voltage (CV)	0V	0V
Resistance (CR)	≒ 1.25Ω	≒ 0.025Ω
INPUT RESISTANCE (LOAD OFF)	100KΩ (Typical)	
SIZE	81(W)× 172(H)×495(D)	
WEIGHT (Approx.)	4.2Kg	
EMC and SAFETY	CE	

MODEL MML-80-120-601		
POWER	60W	600W
CURRENT	0~12A	0~120A
VOLTAGE	1~80V	
MINIMUM OPERATING VOLTAGE (DC)	1.0V at 12A	1.0V at 120A
CONSTANT CURRENT MODE Range	0~12A	0~120A
Resolution	3mA	30mA
Accuracy	0.1%+0.1%F.S.	0.1%+0.2%F.S.
CONSTANT RESISTANCE MODE Range	0.0125Ω~50Ω (600W/16V) 0.625Ω~2.5KΩ (600W/80V)	
Resolution	12 bits	
Accuracy	CRL (50Ω): 0.4mho+0.5% (top) CRH (2.5KΩ): 0.04mho+0.2% (bottom)	
CONSTANT VOLTAGE MODE Range	1~80V	
Resolution	20mV	
Accuracy	± (0.05%+0.1%F.S.)	
DYNAMIC MODE		
DYNAMIC MODE	C.C. MODE	
T1 and T2	0.025mS~10mS / Res: 1μS 1mS~30S / Res: 1mS	
Accuracy	1μS /1mS+100ppm	
Slew Rate	0.002~0.5A/μS	0.02~5A/μS
Resolution	0.002A/μS	0.02A/μS
Current	0~12A	0~120A
Resolution	3mA	30mA
Current Accuracy	0.4% F.S.	
MEASUREMENT SECTION		
VOLTAGE READ BACK		
Range	0~16V	0~80V
Resolution	0.5mV	2.5mV
Accuracy	0.05%+0.05% F.S.	
CURRENT READ BACK		
Range	0~12A	0~120A
Resolution	0.375mA	3.75mA
Accuracy	0.1%+0.1% F.S.	
PROTECTION SECTION		
Over Power Protection	≒ 62.4W	≒ 624W
Over Current Protection	≒ 12.24A	≒ 122.4A
Over Temperature Protection	≒ 85°C	
Over Voltage Protection	≒ 81.6V/16.3V	
GENERAL		
SHORT CIRCUIT		
Current (CC)	≒ 13.2/12A	≒ 132/120A
Voltage (CV)	0V	0V
Resistance (CR)	≒ 0.625Ω	≒ 0.0125Ω
INPUT RESISTANCE (LOAD OFF)	100KΩ (Typical)	
SIZE	162(W)× 172(H)×495(D)	
WEIGHT (Approx.)	8.4Kg	
EMC and SAFETY	CE	

MODEL MML-500-10-301		
POWER	30W	300W
CURRENT	0~1A	0~10A
VOLTAGE	2.5~500V	
MIN. OPERATING VOLTAGE (DC)	2.5V at 1A	2.5V at 10A
CONSTANT CURRENT MODE Range	0~1A	0~10A
Resolution	0.25mA	2.5mA
Accuracy	0.1%+0.1%F.S.	0.1%+0.2%F.S.
CONSTANT RESISTANCE MODE Range	1.25Ω~5KΩ (300W/125V) 50Ω~200KΩ (300W/500V)	
Resolution	12 bits	
Accuracy	5KΩ : 0.02 mho+0.2% 200KΩ : 0.005 mho+0.1%	
CONSTANT VOLTAGE MODE Range	2.5~500V	
Resolution	125mV	
Accuracy	0.05%±0.1%F.S.	
DYNAMIC MODE		
DYNAMIC MODE	C.C. MODE	
T1 & T2	0.025mS~10mS / Res: 1µS 1mS~30S / Res: 1mS	
Accuracy	1µS /1mS+100ppm	
Slew Rate	0.16~40mA/µS	1.6~400mA/µS
Resolution	0.16mA/µS	1.6mA/µS
Current	0~1A	0~10A
Resolution	0.25mA	2.5mA
Current Accuracy	0.4% F.S.	
MEASUREMENT SECTION		
VOLTAGE READ BACK		
Range	0~125V	0~500V
Resolution	4mV	16mV
Accuracy	0.05%+0.05% F.S.	
CURRENT READ BACK		
Range	0~1A	0~10A
Resolution	0.032mA	0.32mA
Accuracy	0.1%+0.1% F.S.	
PROTECTION SECTION		
Over Power Protection	≒ 31.2W	≒ 312W
Over Current Protection	≒ 1.02A	≒ 10.2A
Over Temperature Protection	≒ 85°C	
Over Voltage Protection	≒ 510V/127.5V	
GENERAL		
SHORT CIRCUIT		
Current (CC)	≒ 1.1/1A	≒ 11/10A
Voltage (CV)	0V	0V
Resistance (CR)	≒ 50Ω	≒ 1.25Ω
INPUT RESISTANCE (LOAD OFF)	100KΩ (Typical)	
SIZE	81(W)× 172(H)×495(D)	
WEIGHT (Approx.)	4.2Kg	
EMC & SAFETY	CE	

MODEL MML-500-20-601		
POWER	60W	600W
CURRENT	0~2A	0~20A
VOLTAGE	2.5~500V	
MIN. OPERATING VOLTAGE (DC)	2.5V at 2A	2.5V at 20A
CONSTANT CURRENT MODE Range	0~2A	0~20A
Resolution	0.5mA	5mA
Accuracy	0.1%+0.1%F.S.	0.1%+0.2%F.S.
CONSTANT RESISTANCE MODE Range	0.625Ω~2.5KΩ (600W/125V) 25Ω~100KΩ (600W/500V)	
Resolution	12 bits	
Accuracy	2.5KΩ : 0.05mho+0.2% 100KΩ : 0.005mho+0.1%	
CONSTANT VOLTAGE MODE Range	2.5~500V	
Resolution	125mV	
Accuracy	0.05%±0.1%F.S.	
DYNAMIC MODE		
DYNAMIC MODE	C.C. MODE	
T1 & T2	0.025mS~10mS / Res: 1µS 1mS~30S / Res: 1mS	
Accuracy	1µS /1mS+100ppm	
Slew Rate	0.32~80mA/µS	3.2~800mA/µS
Resolution	0.32mA/µS	3.2mA/µS
Current	0~2A	0~20A
Resolution	0.5mA	5mA
Current Accuracy	0.4% F.S.	
MEASUREMENT SECTION		
VOLTAGE READ BACK		
Range	0~125V	0~500V
Resolution	4mV	16mV
Accuracy	0.05%+0.05% F.S.	
CURRENT READ BACK		
Range	0~2A	0~20A
Resolution	0.0625mA	0.625mA
Accuracy	0.1%+0.1% F.S.	
PROTECTION SECTION		
Over Power Protection	≒ 62.4W	≒ 624W
Over Current Protection	≒ 2.04A	≒ 20.4A
Over Temperature Protection	≒ 85°C	
Over Voltage Protection	≒ 510V/127.5V	
GENERAL		
SHORT CIRCUIT		
Current (CC)	≒ 2.2/2A	≒ 22/20A
Voltage (CV)	0V	0V
Resistance (CR)	≒ 25Ω	≒ 0.625Ω
INPUT RESISTANCE (LOAD OFF)	100KΩ (Typical)	
SIZE	162(W)× 172(H)×495(D)	
WEIGHT (Approx.)	8.4Kg	
EMC & SAFETY	CE	

2 INSTALLATION

2.1 Introduction

This chapter discusses installation of the Load to the Mainframe, Load connections, and unit self-tests, as well as application considerations.

2.2 Inspection

As soon as the instrument is unpacked, inspect any damage that might have occurred in shipping. Keep all packing materials in case the Load or the Mainframe has to be returned. If any damage is found, please file a claim with the carrier immediately. Do not return the instrument to Sorensen without prior approval.

In additon to this manual, be sure that the following items have also been received with your Mainframe and Load:

- Mainframe: Power Cord
- Load Module: Measurement and Load Cables

2.3 Installing the Modules

CAUTION!

Load module can be damaged by electronic discharge (static electricity).
Use standard anti-static work practices when you handle and install modules.
Avoid touching the connector and the circuit board.

The Sorensen MML-4 Mainframe can accommodate four single-width Loads (MML-80-20-102, MML-80-60-301), or two double-width Loads (MML-80-120-601). Loads can be combined in the Mainframe in any order. The Sorensen MML-2 mainframe can accommodate two single-width Loads or one double-width Load. Module installation procedures in both Mainframes are the same. Installing Loads to the Mainframe requires only a screwdriver.

Procedures

1. Disconnect the power cord with the Mainframe power off.
2. Remove any packing materials from the Mainframe.
3. Start installing the modules in the slot (see Figure 2-1).
4. Plug the load module into the slot of the Mainframe along the rail.
5. Lock the module in place by use of the screwdriver (see Figure 2-1).
6. Install each additional module in the slot next to the previous one.

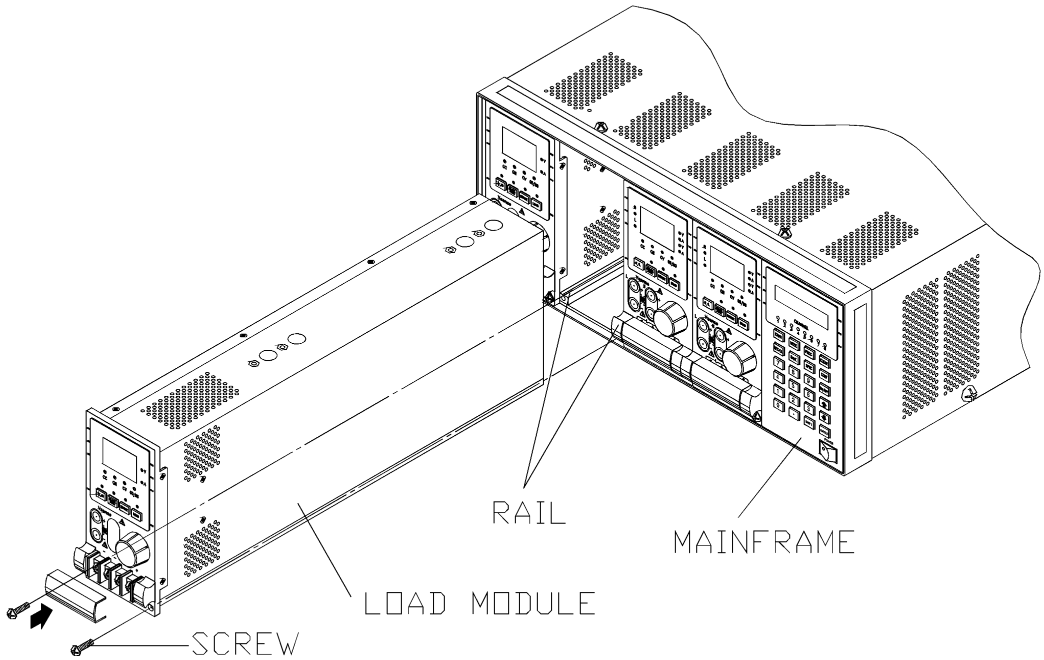


Figure 2-1 Installing Modules in the Electronic Load

WARNING!

If the Mainframe is not installed with all modules, the empty module position must be installed with the panel cover (Sorensen part no. 5361527-06) for safety and airflow.

2.3.1 Channel Number

The channel number of a specific Load is determined by the location of that module in relation to the farthest left side of Mainframe. Because some Load (MML-80-20-102) has two channels in one module, channel 1 and 2 are always on the farthest left slot of the Mainframe, and channel 7 and 8 on the farthest right. The channel number is fixed for Mainframe even Load module is empty. Figure 2-2 shows the channel assignments for a Sorensen MML-4 Mainframe containing two Loads of MML-80-60-301 single channel/module, and two Loads of MML-80-20-102 double channel/module. Channel number is automatically assigned to each channel: 1, 3, 5, 6, 7, 8. At this moment, channels 2 and 4 are empty. MML-2 Mainframe has only four channels (1, 2, 3, 4).

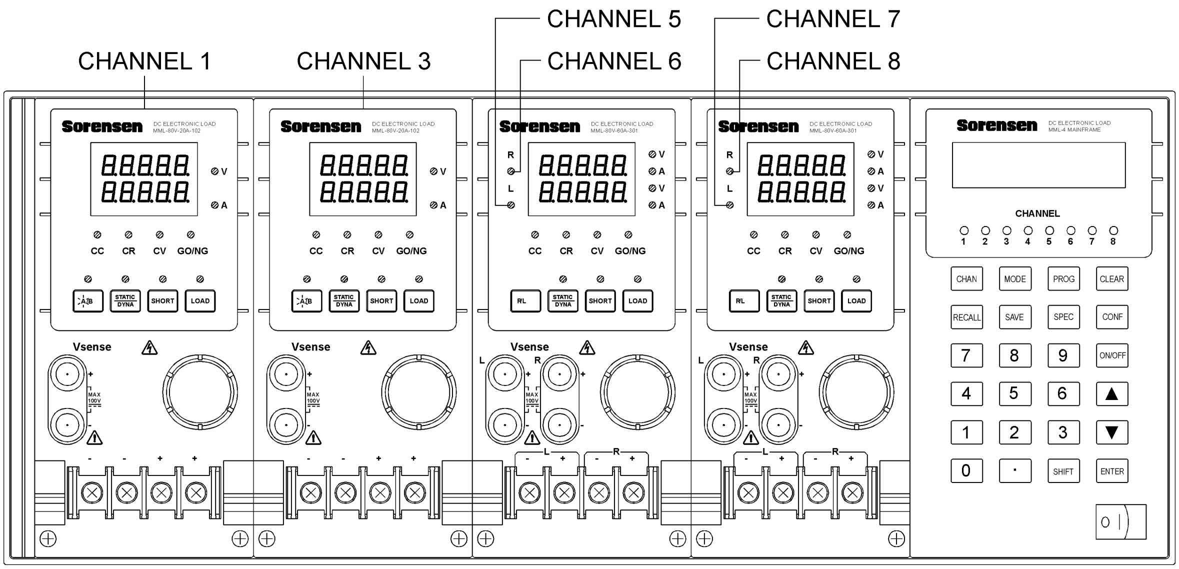


Figure 2-2 Channel Number Example

2.4 Installing the Mainframe

The electronic Load operates properly within a temperature range of 0 to 40º C. However, you must install the electronic Load in a location that has enough space at the top, four sides, and the rear of the unit for adequate airflow. Leave at least 3 cm (1 inch) above the unit for adequate air circulation. Note that the feet of the unit provide vertical space for air circulation when it is stacked. The feet of the Mainframe can be removed for rack mounting.

If you install equipment above the electronic Load in the cabinet, you must use a filter panel above the unit to ensure adequate air circulation. A 1U (EIA standard) panel is sufficient.

2.4.1 Changing Line Voltage

The electronic Load can operate with a 115/230 Vac input as indicated on the rear LINE label. The 100/200 line voltage input model is used only in Japan. If the factory set switch on this label does not correspond to your nominal line voltage, turn the Mainframe power off, and disconnect the power cord. Set switch to the correct line voltage as shown in Figure 2-3.

NOTE: *Line fuses do not need to be changed when the line voltage is changed. The line fuses will protect the electronic Load in any indicated voltage setting.*

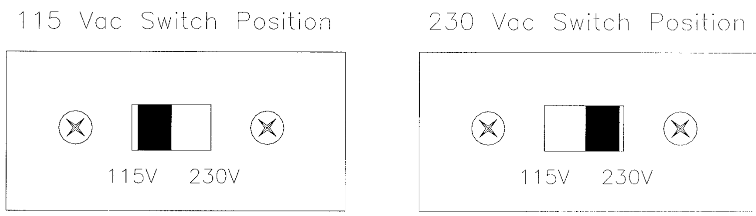


Figure 2-3 Line Voltage Switch

2.4.2 Turn-On Self-Test

Before turning on the Load, check the following:

1. The unit has been factory set to the correct line voltage. Refer to line voltage on the rear panel.
2. The power cord is connected to the AC input socket.

WARNING!

Power provides a chassis ground through a third connector. Be sure that your outlet is of three-conductor type with the correct pin connected to earth ground.

Turn on the Load by the power switch on the front panel of the Mainframe, and observe the display. Immediately after turning on, the electronic Load executes a self-test which checks the GPIB interface board and the input circuitry of the installed modules. All of the LED segments on the front panel are activated momentarily. The Mainframe displays

```
GPIB ADDRESS = 1
```

and then displays

```
LOAD MODULE
CHANNEL SCANing
```

The LCD displays the GPIB address in power-on condition. The GPIB address switch is on the rear panel if the GPIB card is installed. If the GPIB card is not installed, the LCD will show `LOAD MODULE CHANNEL SCANing`. The Mainframe checks the existing channels when the display is `CHANNEL SCANing`. The LEDs on the front panel are activated momentarily. If the Mainframe fails any portion of the self-test, the LED will blink, and the LCD has no display. When self-test completes, the Mainframe will display the active channel which is installed.

The Load module also executes a self-test that checks firmware and communication with Mainframe. All of the LEDs on the front panel are activated momentarily, and the 7-segment LED displays model number as well as firmware version. If any error is found in self-test, the display will stuck here. Check the Load and Mainframe connection when an error occurs. When the self-test completes, the 7-segment will display measurement V and I. The double channel/module goes to L channel.

```
MML-80-60-301   < --- Model Number
    1.02        < --- F/W version
```

Figure 2-4 Module Panel Self-test Display

In case of failure, return the Mainframe or Load module to Sorensen sales or service office for repair.

2.5 Application Connection

2.5.1 Load Connections

WARNING!

To satisfy safety requirements, load wires must be heavy enough not to overheat while carrying the short-circuit output current of the device connected to the electronic Load.

Before connecting load wires to Load module, remove the terminal cover from the Load. Install it after load wires are connected. Input connections are made to the + and – terminal block on the front of each Load module. The major considerations in making input connections are the wire size, length and polarity. The minimum wire size required to prevent overheating may not be enough to maintain good regulation. The wires should be large enough to limit the voltage drop to no more than 0.5V per lead. The wires should be as short as possible, and bundled or tied together to minimize inductance and noise picked up from them. Connect the wire from the PLUS (+) terminal on the module to the HIGH potential output terminal of the power supply (UUT). Connect the wire from the MINUS (–) terminal on the module to the LOW potential output terminal of the power supply (UUT). Figure 2-5 illustrates the typical setup for the Load module to the UUT.

WARNING!

To prevent accidental contact with hazardous voltage, cover of terminal must be installed correctly. Each terminal can carry 40 Amps at most. If input current of Load is over 40 Amps, you must use multiple terminals of connections.

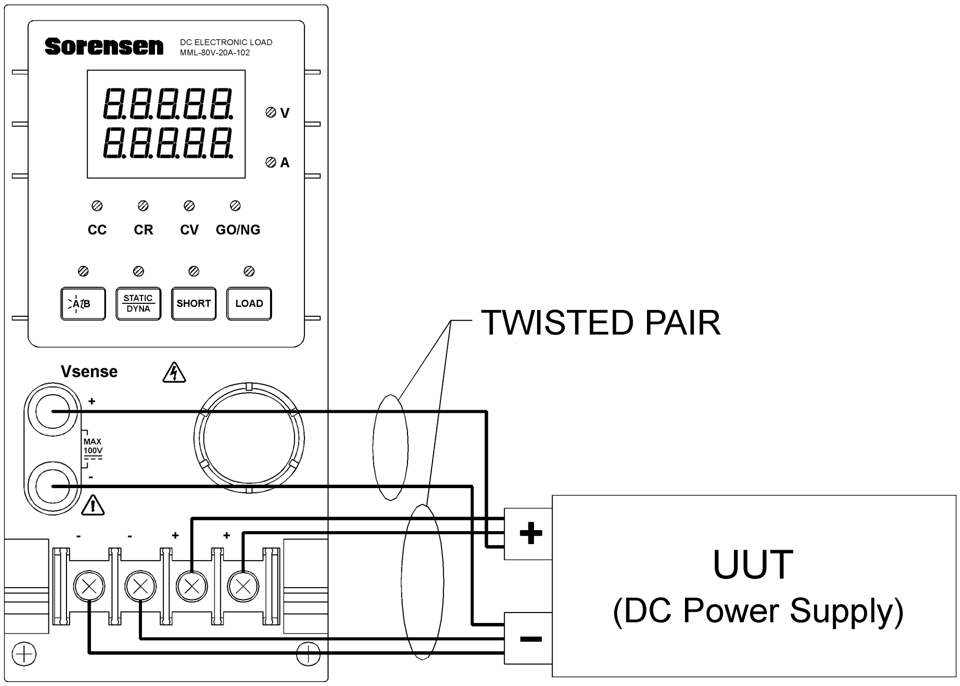


Figure 2-5 Load and Remote Sensing Connection

2.5.2 Remote Sensing Connections

There are two sensing points for the electronic Load module. One is measurement at the Load terminal, and another is measurement at Vsense. The Load module will automatically switch to Vsense when Vsense terminals are connected to UUT, otherwise it will measure at Load terminals. Remote sensing compensates for voltage drop in applications that require long lead lengths. It is useful when a module is operating in CV or CR mode, or when it needs precise measurement. Figure 2-5 also illustrates a typical setup for remote sensing operation.

NOTE: *The potential of Vsense red connector must be higher than that of Vsense black connector.*

2.5.3 Parallel Connections

Figure 2-6 illustrates how modules can be paralleled for increased power dissipation. Modules can be directly paralleled in CC and CR modes of static operation, but cannot be paralleled in CV mode. Each module will dissipate the power it has been programmed. For example, if two modules are connected in parallel, one is programmed 10A, and another 15A, the total current drawn from the source is 25A.

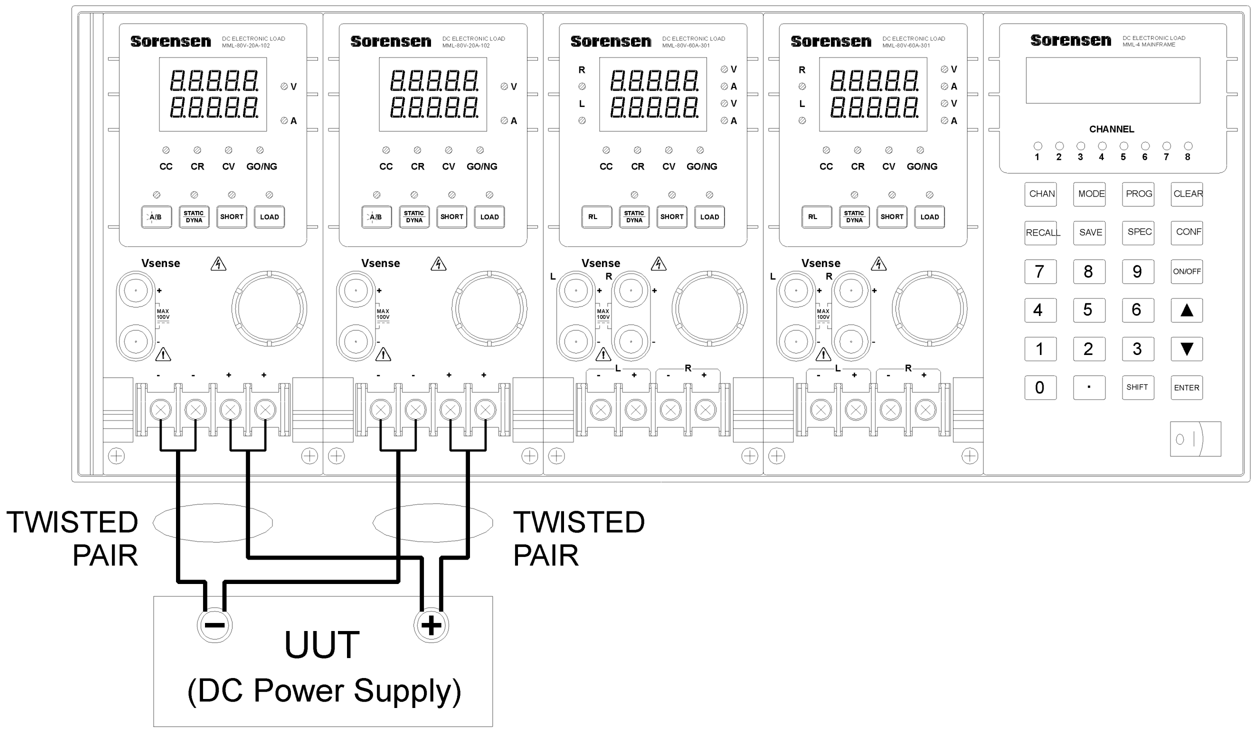


Figure 2-6 Parallel Connections

2.6 Remote Control Connection

The remote operation of Load can be done through GPIB or RS-232C. These connectors on the rear panel connect the Load to the controller or computer.
The GPIB interface of the electronic load is optional. The MML series Remote Controller can control load through RS-232C port. Connect Remote Controller to the electronic Load before powering on. If you have not done thus, Load will shut down, or fuse for remote controller in Mainframe will be broken.

3 OPERATION OVERVIEW

3.1 Introduction

The Sorensen MML-4 and MML-2 multiple electronic load mainframes are used for design, manufacturing, testing and quality assurance. The Mainframe contains four (or two) slots for load modules. Load modules occupy either one or two slots. It depends on the power rating of the module. The Mainframe can dissipate up to 1200 watts when it is full loaded. It contains a processor, GPIB and RS-232C connectors, front panel keypad and display, and PASS/FAIL signals. Built-in remote control functions allow you to control and read back current, voltage, and status. The SYNC function of the Mainframe synchronizes each module when module current/voltage level changes. Save/Recall feature allows you to save up to 100 files, 10 programs, and one default setting. All of them can be saved in Mainframe EEPROM for future use.

The Mainframe contains three (or two) cooling fans, and the module contains one cooling fan. The fan speed automatically increases or decreases as the module power rises or falls. This feature reduces overall noise level because the fans do not always run at the maximum speed.

Each module can operate independently in constant current (CC), constant resistance (CR), and constant voltage (CV) modes. An individual module may have one or two channels. Each of them has its own channel number, contains its own input connectors, and can be turned on/off or short-circuited independently. If your application requires a power or current capacity greater than one module can provide, you must connect the load modules in parallel in CC or CR mode.

Each load module can be independently controlled either remotely via GPIB/RS-232C or locally via a keypad on the front panel. Once a channel is selected or addressed, all subsequent commands go to that channel until another channel is selected or addressed. Operation of all models in the Mainframe is similar regardless of power ratings.

3.2 Front Panel Description

The front panel of Mainframe includes a 16 × 2-character LCD display, 8 (4) channel indicators, and keypads. All parameters of the Load are set through the Mainframe. The LCD display also shows which function is being performed when you use the keypads. Three of the keys perform two functions. The alternative function is labeled in blue above the key. It is selected by pressing the blue SHIFT key and the function key simultaneously.

3.3 Rear Panel Description

The rear panel of Mainframe includes an RS-232C connector, a GO/NG output port, an AC LINE socket, a fuse holder, an optional GPIB connector, and three cooling fans. Figure 3-1 shows the rear panel of the MML-4 Mainframe.

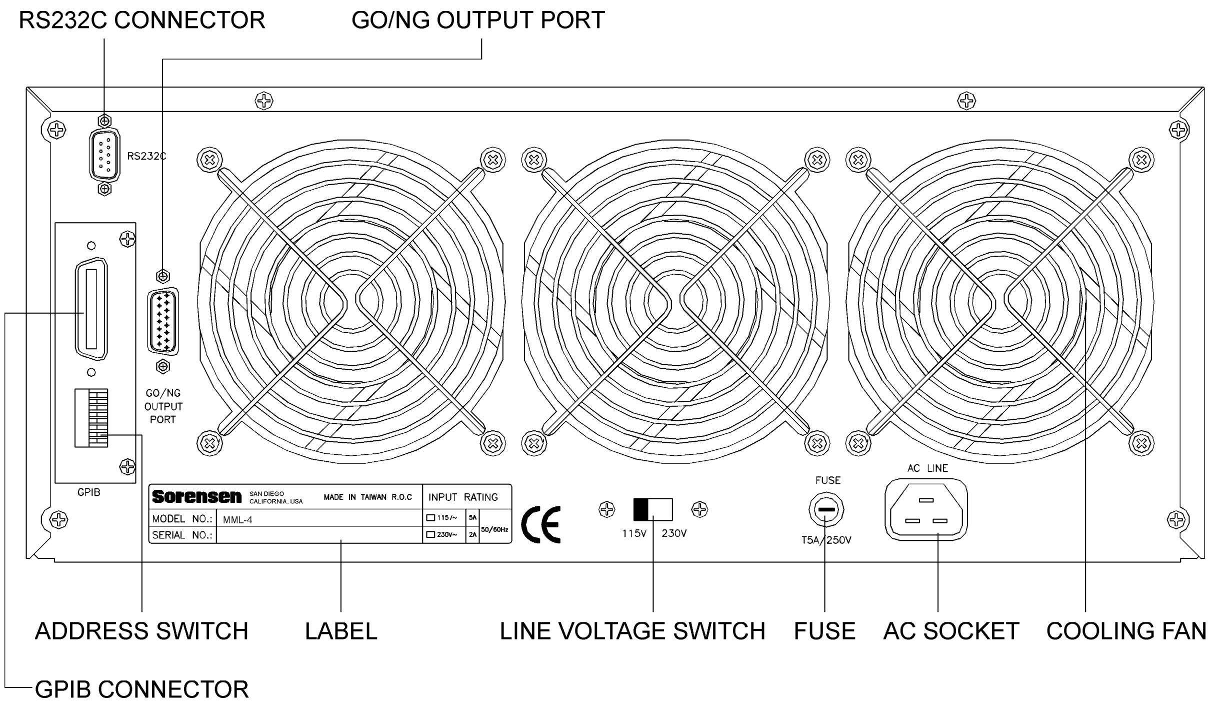


Figure 3-1 Rear Panel of MML-4 Mainframe

3.4 Local/Remote Control

Local (front panel) control is in effect immediately after power is applied. The front panel keypad and display allow manual control of individual modules when the Load is used in bench test applications. Remote control goes into effect as soon as the Mainframe receives a command via GPIB or RS-232C. With remote control in effect, only the computer can control the Load. The front panel keypad has no effect except the LCL key. You can return the Load to local control from remote control by pressing LCL key. The SHIFT key acts as LCL when the Load is in a remote state.

Most of the functions that perform remotely can perform locally too at the front panel of Mainframe. The keypads on the module can perform simple functions like short, load on/off, static /dynamic, and load A/B or display selection R/L.

Instructions for local operation are detailed in Chapter 4.

3.5 Modes of Operation

There are three modes of operation: Constant Current (CC), Constant Resistance (CR), and Constant Voltage (CV).

When you press the ENTER key to program to a mode, a module will change to a new mode. When changing modes, the module's input is momentarily disabled before a new mode is enabled. This ensures that there will be minimum overshoots in change of modes. The parameters in current, resistance or voltage mode can be programmed simply as the mode is presently selected.

All data set in CC/CR/CV mode will be rescaled to fit the resolution of current/voltage levels or slew rate. In local mode, any value can be set to a module from the keypad. There are no upper and lower limits that would cause an error. The Mainframe automatically selects data which are rescaled from the programmed value, truncates and checks the high and low boundaries before fitting memory. When programmed data are over the boundary, the Mainframe will set maximum or minimum level for the Load module. In remote mode, an error will occur when data are over the maximum or minimum value.

3.5.1 Constant Current Mode

Figure 3-2 Constant Current Mode

In CC mode, the Load will sink a current in accordance with the programmed value regardless of input voltage. The CC mode can be set with the MODE key on the front panel. When `MODE SELECT` is displayed, it means to select static low range `CCL` or static high range `CCH`.

Current Ranges (Low, High)

Current can be programmed in either of the two ranges, low range and high range. The low range provides better resolution at low current setting. If any value is over the maximum of low range, you must select the high range. Press the MODE key first, then use the UP or DOWN key to select the current range.

MODE SELECT CCL	Select Static Constant Current low range
MODE SELECT CCH	Select Static Constant Current high range
MODE SELECT CCDL	Select Dynamic Constant Current low range
MODE SELECT CCDH	Select Dynamic Constant Current high range

Select range by pressing the ENTER key.

Changing the mode or the range affects the module. Both cause the input to go through an off state. If the CC mode of Load module is active, the new setting will immediately change the input at a rate determined by the slew rate setting.

STATic/DYNAmic Functions

In CC mode two operation functions (STATic, DYNAmic) can be selected. STATic function checks the stability of output voltage from a power supply. In some modules (single channel/module) there are two current levels (A or B) for static function. Both states A and B use the same range. You can select A (CCL1 or CCH1) or B (CCL2 or CCH2) through the A/B key on the module's keypad or Mainframe keypad when level1 (A) or level2 (B) changes. Slew rate determines the rate at which Load level changes from one load level state to another. Figure 3-3 shows current level of load module after pressing of A/B key.

CCL1:4A, CCL2:2A, CCL ⟋: 0.2A/µS, CCL⟍: 0.08A/µS

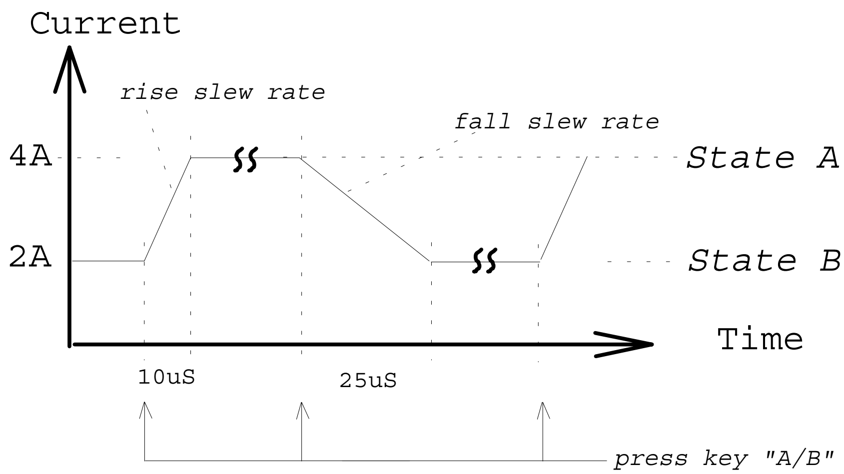


Figure 3-3 Load Level after Pressing A/B Key

Dynamic load operation enables you to program two load levels (CCDL1, CCDL2), load duration (CCDLT1, CCDLT2), and slew rate (CCDL _/¯, CCDL¯_). During operation, the loading level is switched between those two load levels according to your specific setting. The dynamic load is commonly used in the test of UUT's performance under transient loading condition. Figure 3-4 shows current waveform of dynamic function.

CCDL1:4A, CCDL2:2A, CCDL _/¯:1A/μS, CCDL¯_: 1A/μS, CCDLT1:10mS, CCDLT2:10mS

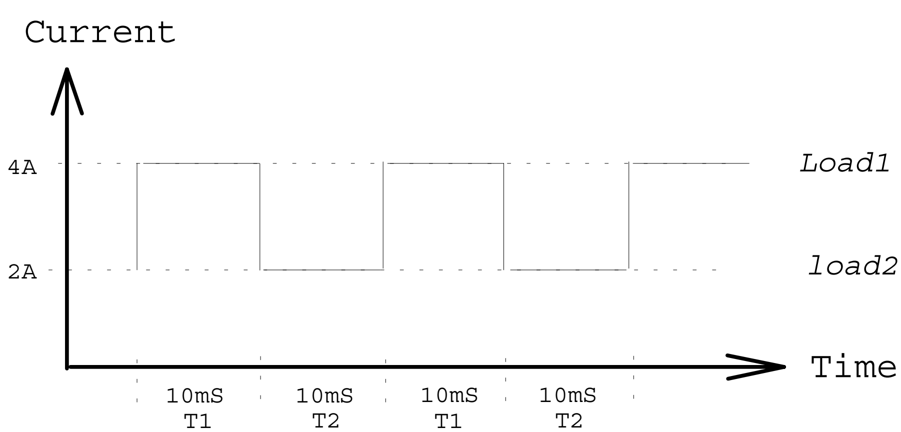


Figure 3-4 Dynamic Current Waveform

The STATic/DYNAmic functions can be also selected through STATIC/DYNAMIC key on the Load module.

Slew Rate (Rise, Fall A/µS or mA/µS)

Slew rate determines the rate at which the current input of a module changes to a newly programmed vlaue. There are two slew rate values. One is for rise rate, and another for fall rate.

Voltage Ranges (Low, High)

There are two voltage ranges for voltage measurement and Von voltage setting. The low range provides better resolution at low voltage measurements. If any value is over the maximum of low range, you must select the high range. The voltage range selection of CC mode is in configuration setting.

3.5.2 Constant Resistance Mode

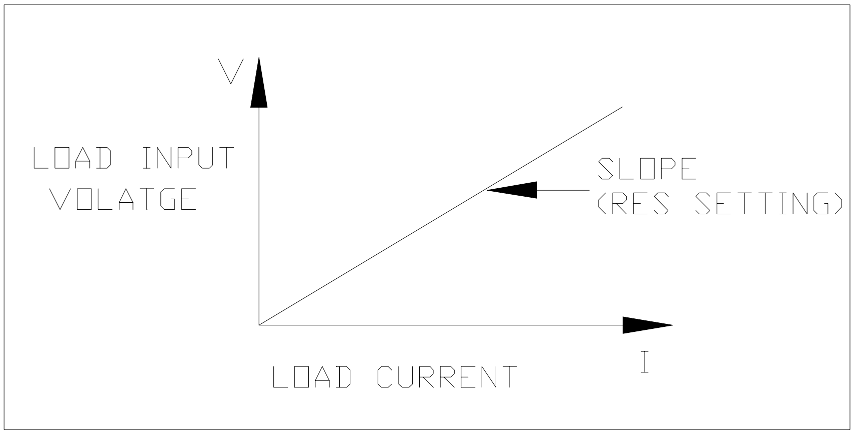


Figure 3-5 Constant Resistance Mode

In CR mode, the Load will sink a current linearly propotional to the input voltage in accordance with the programmed resistance. There is a double pole RC filter of input voltage, so high frequency parts will be removed. The time constant of low pass filter is about 4.7 mS.

Voltage Ranges (Low, High)

Resistance can be programmed in either of the two ranges, low range and high range. The low range is used for input voltage in low voltage range while the high range for input voltage over low voltage range. The current range of CR mode is high range.

MODE SELECT CRL	Select Constant Resistance low voltage range
MODE SELECT CRH	Select Constant Resistance high voltage range

Select range by pressing ENTER key

If input voltage is over the maximum of low range, you must select the high range. Press MODE key first, and then use the UP or DOWN key to select voltage range. In some modules (single channel/module) there are two resistance levels (A or B) for CR function. Both states A/B use the same range. You can select A (CRL1 or CRH1) or B (CRL2 or CRH2) through A/B key on the module's keypad. Slew rate determines the rate at which load level changes from one load level state to another.

Slew Rate (Rise, Fall A/µS)

Slew rate in constant resistance mode is programmed in Amps/second.

3.5.3 Constant Voltage Mode

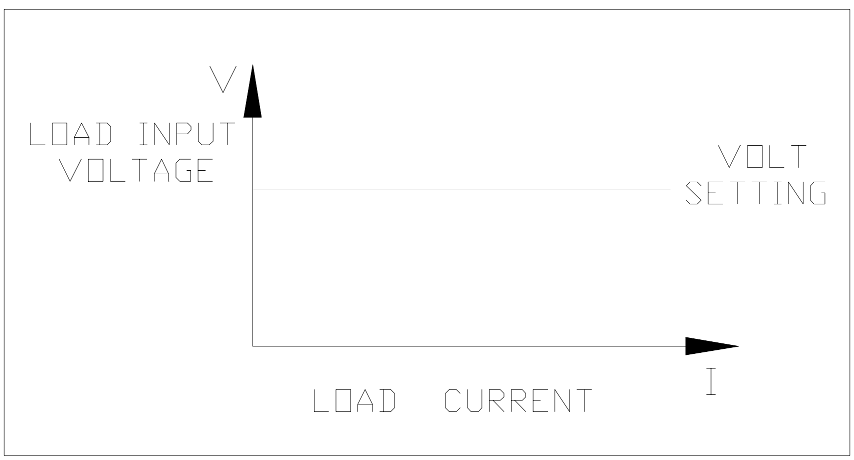


Figure 3-6 Constant Voltage Mode

In CV mode the Load will sink current to control the voltage source in programmed value. In some modules (single channel/module) there are two voltage levels (A or B) for CV function. You can select A (CV1) or B (CV2) through A/B key on the module's keypad. There are two response speeds of CV modes: fast and slow. The fast/slow respond speed means the slew rate of current change.

Voltage and Current Range (High)

The voltage and current range of CR mode is high range.

3.6 Load Synchronization

The Sorensen MML-4/MML-2 multiple electronic load mainframes contain eight and four load channels respectively. The channel on/off or change of load timing is important. You can set module change synchronously through SYNC RUN in configuration setting. If a channel is set at SYNC RUN ON, it means that channel on/off or change of load level is synchronized with other Load modules. In other cases channel on/off can be controlled only by the module's LOAD key.

3.7 Measurements

Each module measures current and voltage of the UUT. The sampling rate is about 12 mS. Voltage and current measurements are performed with a 15-bit resolution of full scale ratings.

3.8 Slew Rate and Minimum Transient Time

Slew rate is defined as the change in current over time. A programmable slew rate allows a controlled transition from one load setting to another to minimize induced voltage drops on inductive power wiring, or control induced transients on a test device. If the transient from one setting to another is large, the actual transient time can be calculated by dividing the current transition by the slew rate. The actual transition time is defined as the time required for the change of input from 10% to 90% or from 90% to 10% of the programmed excursion. If the transition from one setting to another is small, the small signal bandwidth of Load will limit the minimum transition time for all programmable slew rates. Because of the limit, the actual transition time is longer than the expected time based on the slew rate. Therefore, both minimum transition time and slew rate must be considered in the determination of actual transition time. The minimum transition time is from 24 μS to 6 mS. It depends on slew rate setting.

3.9 Start/Stop Sink Current

In the simulation of transient characteristics of load to UUT, the critical problems are when and how the Load starts sinking current to UUT. You may set the conducting voltage Von to solve the problems. The Load will start or stop sinking current when the output voltage of UUT reaches the Von voltage. You can start sinking current when setting is load ON, and the input voltage of the module is over Von voltage, but stop sinking when load OFF, or the input voltage below Von voltage. For start and stop sinking current, refer to figure 3-7 and 3-8 separately.

There are two operation modes for Von control. One is latch, and another non-latch. Latch means that when voltage is over Von voltage, Load will start sinking current continuously in spite that input voltage drop is below Von voltage. Non-latch means that when input voltage is below Von voltage, Load will stop sinking current. The Von voltage and operation mode of Von is set in configuration.

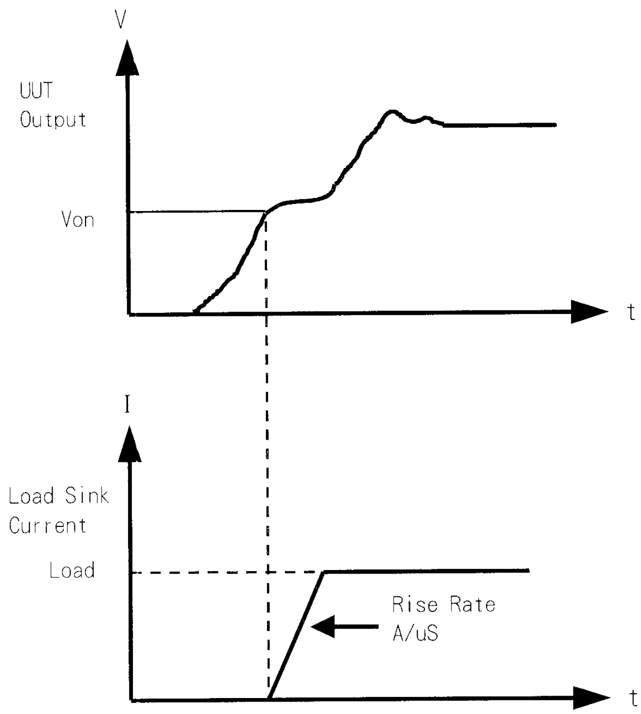


Figure 3-7 Start Sinking Current (Von Non-Latch)

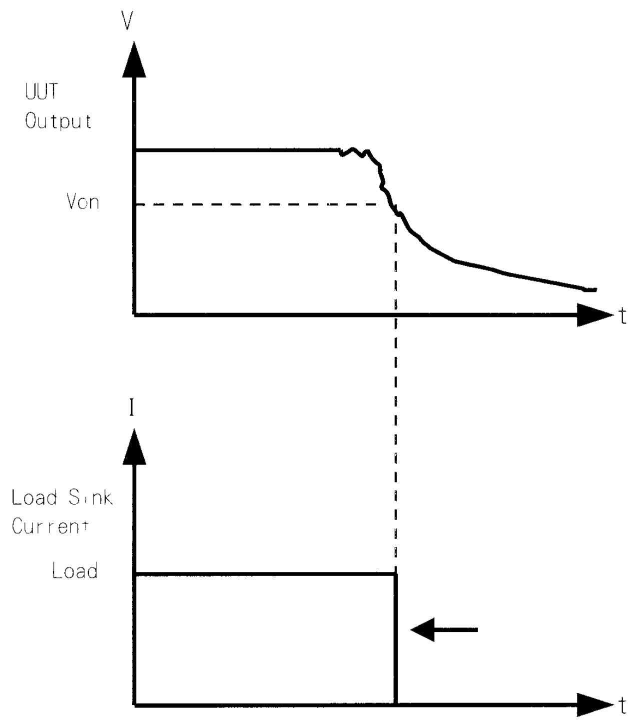


Figure 3-8 Stop Sinking Current (Von Non-Latch)

3.10 Short On/Off

The Load module can simulate a short circuit at its input by setting the load on with full-scale current. The short circuit can be toggled on and off at the front panel or via remote control. There are two operations for SHORT key on the front panel. One is toggled on/off, and another controlled by key. They are selected in configuration. The SHORT key will be enabled only when Load is ON.

Toggled on/off means pressing the SHORT key once to enable short circuit, and again to disable. Control by Key means pressing and holding the SHORT key to enable short circuit, and releasing it to return to normal operation.

The actual value of an electronic short depends on the mode and range that are active when the short is turned on. In CC mode, it is equivalent to programming approximately 110% full-scale current about 30mS for the present current range, and then going to rating current. In CR mode, it is equivalent to programming the minimum resistance for the present resistance range. In CV mode, it is equivalent to programming zero voltage. Turning on the short circuit does not affect the programmed setting, and Load input will return to the previously programmed values when the short circuit is turned off.

Note that turning on the short circuit may cause the Load to sink so much current to trig protection circuit, and that will turn off the Load.

3.11 Load On/Off

A module's input can be toggled on and off through the ON/OFF key on the front panel of the Mainframe, or the LOAD key on the module or the remote control. The on/off change of input is done according to the slew rate.

Turning off the load does not affect the programmed setting. The load will return to the previously programmed values when the Load is turned on again.

3.12 Protection Features

Each load module includes the following protection features: Overvoltage, Overcurrent, Overpower, Overtemperature, and Reverse Voltage.

The appropriate bits in the Mainframe's statue registers are set when any of the protection features mentioned above is active. Besides, the Load's buzzer will produce beep sound to inform you until protection status is reset. When any protection occurs, it will cause the Load input to be turned off.

3.12.1 Overvoltage

The overvoltage protection circuit is set at a level slightly above the voltage range specified in the specification of the Load. The overvoltage (OV) and voltage fault (VF) status register bits are set when the OV condition occurs. They will remain set until they are reset. The Load module will display ovP when overvoltage protection occurs.

3.12.2 Overcurrent

When the Load is operating in CR or CV mode, it is possible for a module to attempt to sink current more than it is rated for. The limit level of current is set at a level slightly above the current of the Load. The overcurrent (OC) and current error (CE) status register bits are set when the OC condition occurs, and will remain set until they are reset. The Load module will display oCP when overcurrent protection occurs.

3.12.3 Overpower

The overpower protection circuit is set at a level slightly above the power range specified in the specifications of the Load. The overpower (OP) and power error (PE) status register bits are set when the OP condition occurs, and will remain set until they are reset. The Load module will display oPP when overpower condition occurs.

3.12.4 Overtemperature

Each Load has an overtemperature protection circuit that will turn off the load if the internal temperature exceeds a safe limit. The overtemperature (OT) and temperature error (TE) status register bits are set when the condition occurs, and will remain set until they are reset. The Load module displays otP if an overtemperature condition occurs.

3.12.5 Reverse Voltage

The Load conducts a reverse current when the polarity of the UUT connection is not correct. The maximum safe reverse current is the same as the rated current of the Load. If the reverse current of the UUT is over the rated current of the Load, the Load may be damaged. If a reverse voltage condition is detected, you must turn off power to the UUT immediately, and make a correct connection. The reverse voltage (RV) and voltage fault (VF) status register bits are set when the RV condition occurs, and will remain set until they are reset. The Load module will display rEv when reverse voltage protection occurs.

All of the protection features will latch when they are tripped. When any protection occurs the module will turn off the load input, and produce beep sound until you remove the condition and reset protection by pressing LOAD key on the module.

CAUTION!

To protect the electronic Load from possible damage, the input voltage must not exceed the maximum input voltage rating specification. In addition, the Load +Terminal potential must be more than –Terminal potential.

3.13 Save/Recall Setting

The setting of the electronic Load for all channels can be saved and recalled for use in various test setups. This simplifies the repetitive programming of different things. The present setting of mode parameters (CC, CR, CV), programs and power on status (DEFAULT) can be saved in the EEPROM using SAVE key. Later you can recall the settings from the specified file using RECALL key. The SAVE and RECALL keys affect all channels simultaneously.

3.14 Program

The program feature is so powerful. It allows you to simulate various test conditions. There are ten programs in the electronic Load. Each program has ten sequences. The setting mapping of program sequence to file is one to one. It means that program 1, sequence 1 maps to file 1, and program 3, sequence 4 maps to file 24.

4 LOCAL OPERATION

4.1 Introduction

This chapter describes how to operate the electronic load from the local panel in details. The descriptions include: Mainframe panel control, Module panel control and indicators.

4.2 Local Operation of Load Mainframe

In order to use the front panel keys to control the electronic load, local operation must be in effect. Immediately after power is applied, local operation will be in effect. When local operation is in effect, you can select a channel, and use the display as well as keypad on the front panel to control the Load. The display of Mainframe can be used to view the programmed setting of a selected channel. The input voltage/current is displayed on module's display. The mainframe will scan module type at power-on, and memorize it for channel setting.

NOTE: *When you edit setting, the display will blink setting, and let you know that the active setting is to be edited or selected.*

In the remote state, the keys on the front panel will have no effect. Only the remote controller can program the Load. The display of module will show the present input voltage and current readings or the last display while the local state is in effect. The display of the Mainframe will show REMOTE message.

NOTE*:* *When setting the load module level, the resolution of current, voltage, resistance, and slew rate setting will be different from the entered values. The displayed or stored value of the setting will be the actual value of D/A programmed in the load module. The current, voltage, and slew rate setting will be degraded as lower values are entered. The resistance setting will be degraded as higher values are entered.*

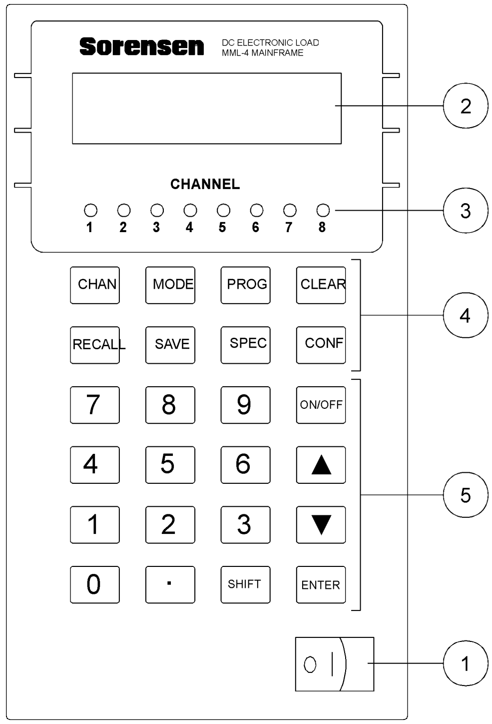


Figure 4-1 Front Panel of Mainframe

① **Power Switch**. Turns the AC power on and off.

② **LCD Display**. Displays channel information.

③ **Channel Indicator**. Indicates the active channel settings.

④ **Function keys:**

CHAN. To select a channel for settings.

MODE. To select a mode for settings.

PROG. To select a program for settings or running.

CLEAR. To clear the digit entered from keypad. This key allows you to change incorrect digits before they are entered.

RECALL. To recall the saved settings from EEPROM, and all channels' settings from specified files (1 to 101). Recalling file 101 means to recall the factory default settings. Recalling program is from PROG, number 1 to 10.

SAVE. To save all of the present mode settings of all channels in the specified files (1 to 100). Saving program is from 1 to 10. Saving DEFAULT is to save the status of all channels for the next time the electronic Load is turned on. All saved settings are stored in EEPROM, and will not be lost when ac power is cycled.

SPEC. To select specification data for editing, or to enable SPEC function.

CONF. To select configuration data for editing.

⑤ **Entry keys:**

∧ and **V**. The UP and DOWN keys allow you to scroll through the choices in a parameter list that is applied to a specific command. Parameter lists are circular; you can return to the starting position by pressing either of the keys continuously.

ON/OFF. Toggles the output of the electronic Load between on and off states if channel SYNC. RUN is set to ON.

ENTER. Executes the entered value or the parameter of the presently accessed command. The parameters you have entered with other keys are displayed but not entered into the Load until you press this key. Before pressing ENTER you can change or abort anything previously entered into the display.

SHIFT. Enables a shifted key to function (LOCK, SYS). When in remote control state, this key acts as a local key.

1 – 9 Used to enter numeric values.

. Decimal point.

4.2.1 Selecting the Channel

The CHAN key is used to select one of the channels for local control. See channel number in 2.3.1. To edit channel settings, you must select a channel first. If the channel does not exist, it cannot be selected. If no module is installed in the mainframe, the display will show `DUMMY CHANNEL`. When you press CHAN, the channel number you want to select will automatically increase to the next existing channel. The mainframe will scan the module type at power-on, and memorize it for channel editing.

4.2.2 Setting the Operation Mode

The MODE key and the **∧** and **V** keys are used to select modes of channels for local control. Press MODE to display the selected channel's active mode. The active mode can be changed by use of the **∧** or **V** key followed by the ENTER key. The sequence of mode selection after pressing the **V** key is as follows:

CCL -> CCH -> CCDL -> CCDH -> CRL -> CRH -> CV go back to CCL.

Press the ENTER key to select the mode and confirm the setting.

NOTE: *The eight operation modes of load module settings stored in the mainframe are independent. Changing one mode setting will not affect other modes. Storing the settings to EEPROM (1-100) will store only one mode setting.*

The load levels and slew rates are common to CC and CR modes. CV mode sets voltage level and response speed. There are two level settings for a single channel/ module of CC, CR, and CV modes. They can be switched by the module's A/B key.

Setting CC Values

There are four modes for CC operation: CCL, CCH, CCDL, CCDH. The current levels are programmed in Amps. The slew rate levels are programmed in milliamps/µS at low range and in Amps/µS at high range. The timings are programmed in milliseconds. The setting buffers of four CC modes are independent. Changing the operation range does not affect the settings of other ranges.

The following examples illustrate how to set the CC values of Load module for model MML-80-60-301. Before observing the examples, select channel first.

1. Select Range/Function

   Press MODE, use the **∧** or **V** key to select CCL, then press ENTER.

   CCL: static low range
   CCDL: dynamic low range
   CCH: static high range
   CCDH: dynamic high range

   ```
   MODE SELECT
   CCL
   ```

2. Set Current Level

   There are 4000 discrete steps from 0 to full scale in each range. Set level1 (A) current level to 2 amps by pressing 2, ENTER. Set level2 (B) current level to 1 amp by pressing 1, ENTER.

   ```
   CCL1:   1.9995A
   CCL2:   0.9990A
   ```

3. Set Slew Rate

   There are 250 discrete steps in each range. Set the rise 50 mA/µS and fall slew rates to 50 mA/µS by pressing 5, 0, ENTER for rise and 6, 0, ENTER for fall slew rate.

   ```
   CCL    : 50mA/µS
   CCL  : 60mA/µS
   ```

4. Set DYNAmic Function Periods
   Dynamic function has period T1 and T2 to be set. Set dynamic period 1 to 0.1 mS, period 2 to 0.2 mS by pressing 0, ., 1, ENTER and 0, ., 2, ENTER. The range of Dynamic period is from 0.025 µS to 30 sec.

```
CCDLT1:  0.100mS
CCDLT2:  0.200mS
```

NOTE: *If you press the ENTER key, and the blinking data do not go to next, change configuration setting Enter Data Next to YES.*

Setting CR Values

To program the CR values for the selected channel, press the MODE, **∧**, and ENTER keys. The resistance values can be programmed in low voltage (CRL) or high voltage (CRH) range. The current is always in high range. ALL resistance levels are programmed in ohms. The slew rate is in A/µS.

The following examples illustrate how to set CR values of Load module for model MML-80-60-301.

1. Select Range
   Press MODE, and use the **∧** and **V** key to select CRL, then press ENTER.

```
MODE SELECT
CRL
```

2. Set Resistor Level
   There are 4000 discrete steps from 0 to full scale in each range. Set the main resistor level1 (A) to 2 ohms by pressing 2, then ENTER. Set the level2 (B) resistor level to 1 ohm by pressing 1, then ENTER.

```
CCL1:  2.000Ω
CCL2:  1.000Ω
```

3. Set Slew Rate
   There are 250 discrete steps in each range. Set the rise and fall slew rates to 0.1 A/µS by pressing ., 1, then ENTER for rise slew rate and ., 2, then ENTER for fall slew rate.

```
CRL ╱‾: 0.10A/µS
CRL ‾╲: 0.20A/µS
```

Setting CV Values

Set the CV values for the selected channel by pressing MODE, **∧**, and then ENTER keys. The voltage values can be programmed in one range. The voltage levels are programmed in volts. The response speed is programmed in fast/slow operations.

The examples below illustrate how to set CV values of the Load module for model MML-80-60-301. Before following the examples, select channel first.

1. Select Range
   Press MODE and use the **∧** or **V** key to select CR followed by ENTER key.

```
MODE SELECT
CV
```

2. Set Voltage Level
   There are 4000 discrete steps from 0 to full scale in each range. Set the main voltage level1 (A) to 5 volts by pressing 5, ENTER. Set the level2 (B) voltage level to 6 volts by pressing 6, then ENTER.

```
CV 1:  5.00V
CV 2:  6.00V
```

3. Set Response Speed
   There are two response speeds for CV mode, fast and slow, for different UUT testing. For demanding load tests, use the fast response speed. Refer to Figures 4-2 and 4-3 for transfer functions.

```
CV RESPONSE
1:FAST 2:SLOW
```

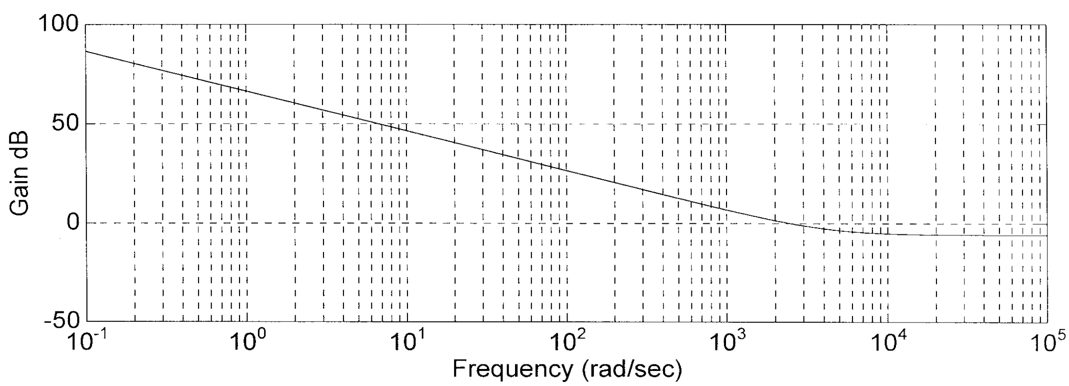


Figure 4-2 CV Response Transfer Function (FAST)

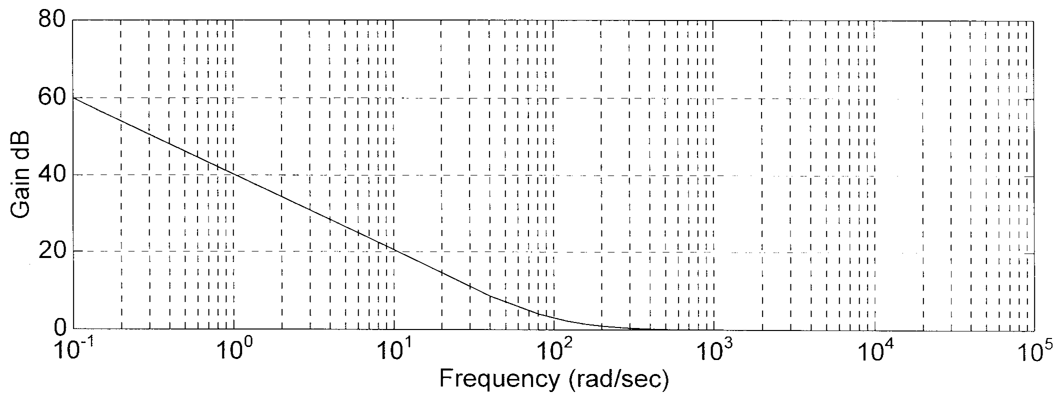


Figure 4-3 CV Response Transfer Function (SLOW)

4.2.3 Setting the Program

The electronic Load is able to select customized basic tests, and link them into a program test for automatic execution.

The PROG key is used to select a program, or recall a program for local control. There are ten programs (1-10). Each program has ten sequences to map files from 1 to 100. Program 1 maps files from 1 through 10. Table 4-1 shows the relationship between the program sequence and the corresponding file.

Program 1 Sequence No.	1	2	3	4	5	6	7	8	9	10
Corresponding File No.	1	2	3	4	5	6	7	8	9	10
Program 2 Sequence No.	1	2	3	4	5	6	7	8	9	10
Corresponding File No.	11	12	13	14	15	16	17	18	19	20
:										
:										
Program 10 Sequence No.	1	2	3	4	5	6	7	8	9	10
Corresponding File No.	91	92	93	94	95	96	97	98	99	100

Table 4-1 Relationship Between Program Sequence and Corresponding File

When running a program, you must set its corresponding file parameters first. If one program sequence is not enough for you to test the UUT, you can use the program chain function to get more sequences.

Press the PROG key, and the LCD will display as follows. Press number 1 -10 followed by ENTER to recall a program from EEPROM, or use the **∧** and **∨** keys to edit the program.

```
PROGRAM SELECT
No:  1
```

1. Setting the Active Channels
   The LCD displays the active channels for the program to control. The LED channel indicators will be active if the channel is active. The channel can be active only when it exists and the mode of SYNC. RUN is ON. When the channel is not selected, or does not exist, the channel number will not be displayed. Press numbers 1 to 8 to enable or disable the active channel.

```
ACTIVE CHANNEL
1   3  5 6 7 8
```

2. Setting the Program Chain
   The chain function enables you to chain programs together to allow a greater number of sequences for testing. Setting the program chain number to 0 means no programs have been chained. Program chain function can chain itself for loop test, or chain other programs. Press 1, then ENTER to set chain itself for loop test. The default setting is 0.

```
PROGRAM CHAIN
No:  1
```

3. Setting the Sequence P/F Delay Time
   The sequence Pass/Failure delay time allows you to set the delay time for P/F checking when the load condition changes. The failure status of the sequence will latch when a program is executed. It means that any failure will be memorized even when the UUT becomes stable within the specifications later. The P/F delay time range is from 0 to 60 seconds. Press 1, then ENTER to set the sequence P/F delay time to 1 second. The default setting is 0.

```
SEQ. P/F DELAY
TIME:    1.0Sec
```

4. Setting the Sequence ON/OFF Time
   The sequence ON/OFF time controls the Load input ON/OFF when the program sequence is executed. The range of ON/OFF time is from 0 to 60 seconds.

```
SEQ. ON TIME
TIME:  1.00Sec
```

Press 0, then ENTER to set OFF time to 0 seconds. The default setting is 0 seconds for OFF time.

```
SEQ. OFF TIME
TIME:    0.00Sec
```

5. Setting the Sequence Mode
   There are three modes to control the method of sequence execution.

   - SKIP: Skip the sequence. Load will not change input status.
   - AUTO: Use ON/OFF time to control Load input on/off. When ON/OFF time passes, the Load will get to the next sequence automatically.
   - MANUAL: Use the **∧** or **V** key or numbers 0 to 9 to control the execution

     sequence. Pressing number keys allows random selection of sequence numbers to execute. Pressing 0 means to go to sequence 10.

   Press 2, then ENTER to set sequence 1 to manual mode. You must set ten sequence settings for one program. The default setting is SKIP.

```
SEQ  1:  SKIP=0
AUTO=1  MANUAL=2
```

6. Setting the Short Channel
   When the sequence mode is not SKIP, you must set the short channel and time. The short channel is selected as an active channel. To select the short channel, press numbers 1 through 8 to enable or disable the corresponding module's short function.

```
SEQ. 1 SHORT  CH.
1     3    5 6  7 8
```

7. Setting the Short Time
   The short time range is from 0 to 30 seconds. The short time must be ≤ SEQuence ON time. If the short channel is not selected, or the short time is set to 0 seconds, the selected channel will not short. The default setting is channel 0 and 0 seconds.

```
SEQ. 1
SHORT TIME= 0.0S
```

4.2.4 Running the Program

Press ON/OFF to run program when program function is selected. The LED channel indicators will be active if channel is active. The display shows as follows.

```
PROG. 1 SEQ. 1
[ON] [KEY] [PASS]
```

The upper line displays the executed program and sequence number while the lower line Load, key and test result status.

ON/OFF	:	It shows Load input status.
KEY	:	It displays when MANUAL mode is active and waiting key input.
PASS/FAIL	:	It shows the test result compared with SPEC setting.

When the program is executed, the setting of sequence will recall files from EEPROM, and the SPEC function is always ON. All function keys are disabled until ON/OFF is pressed to stop the program, or program run finishes. When the program is stopped or finished, the LCD will display the following:

```
PROGRAM OFF
RESULT :PASS
```

It means that in testing the program, all sequences have passed. If the test fails, the LCD will display the following.

```
PROG. XX :  1 2
3  4 5 6 7 8 9 10
```

PROG. XX (1 through 10) stands for the file number of the program that failed. In addition, 1, 2, 3...10 appears in the display to indicate the failed sequence numbers. The failed sequences are the results of all failed channels. The LED of the failed channel will be illuminated. In the test by program chain, if the failed program files are more than one set, you can use **∧** and **V** to read the contents of failed programs.

4.2.5 Setting the Specifications

The SPEC key is used to enable or disable the SPEC function, or to set specifications. The Load will compare measurement data with the set specifications of HIGH and LOW boundary when the SPEC TEST is ON, and the LED, GO/NG, is lighted on the module panel. To set specifications for a module, you must go to mode editing by pressing MODE, ENTER, and then the SPEC key.

In other operation modes, pressing SPEC will enable or disable the SPEC TEST function. The SPEC TEST ON/OFF function is global. It means that all modules installed on the Mainframe will do GO/NG comparison. The specification unit of CC and CR modes is volts while that of CV mode is current. There are three levels for each mode: CENTER, HIGH, and LOW. The CENTER level must be set by the value of channel input reference level. The HIGH and LOW levels can be set by the value or percentage selected in configuration SPEC. ENTRY MODE. The HIGH/LOW percentage range is from 0 to 100%.

Press MODE, ENTER, SPEC to set the specifications of CC mode. Press 5, ENTER to set CENTER level 5V.

```
VOLTAGE SPEC.
CENTER: 5.0000V
```

Press 5, ENTER to set HIGH level 5%.

```
VOLTAGE SPEC.
HIGH PCet:  5.0%
```

Press 5, ENTER to set LOW level 5%.

```
VOLTAGE SPEC.
LOW Pcet:   5.0%
```

The default setting of HIGH and LOW is 100%. The CENTER value is half of the range. To select the specifications set by Value or Percentage, please refer to 4.1.6.

4.2.6 Setting the Configuration

The electronic Load provides useful features such as Von point, Current limit, and Sync run. To use these powerful features, use the configuration setup procedures to set the parameters relevant to your application needs. This procedure is only needed for initial setup of a test operation. The configuration of each channel is stored independently in the EEPROM of the Mainframe. To set configuration you must press CONF.

Set the voltage range of CC mode. There are two voltage ranges for CC mode. High range is for high voltage and low range is for low voltage to get better voltage resolution. The default setting of Vrange is HIGH.

```
CC Vrange Select
1:HIGH   2=LOW
```

Set Von point. Von is the conduction voltage level when the electronic Load starts to sink current and the UUT output reaches the Von voltage. The default setting of Von voltage is 1V.

```
Von POINT
VOLTAGE: 3.50V
```

Set Von latch. There are two operation modes for Von control. Von latch ON means that Load will sink current continuously when Von voltage reaches. Von latch OFF means that Load will stop sinking current when UUT voltage is under Von voltage. The default setting of Von latch is OFF. Figures 4-4 and 4-5 show Von LATCH ON and OFF current waveform separately.

```
Von LATCH
1:ON   2:OFF
```

CAUTION!

Do not set Von to 0V. This will cause an overshoot spike because the Load circuit will be ON regardless of no UUT. If a UUT is applied, the overshoot may damage the UUT regardless of the minimal current setting of the Load.

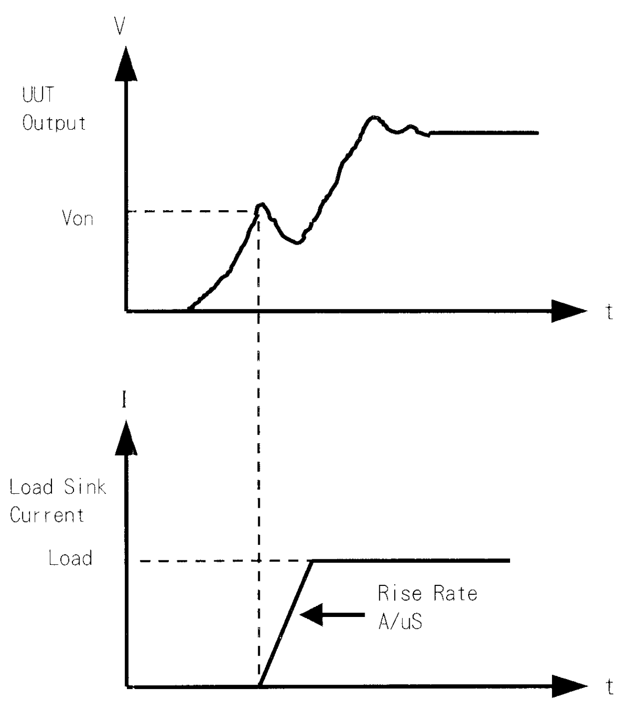


Figure 4-4 Von LATCH ON Current Waveform

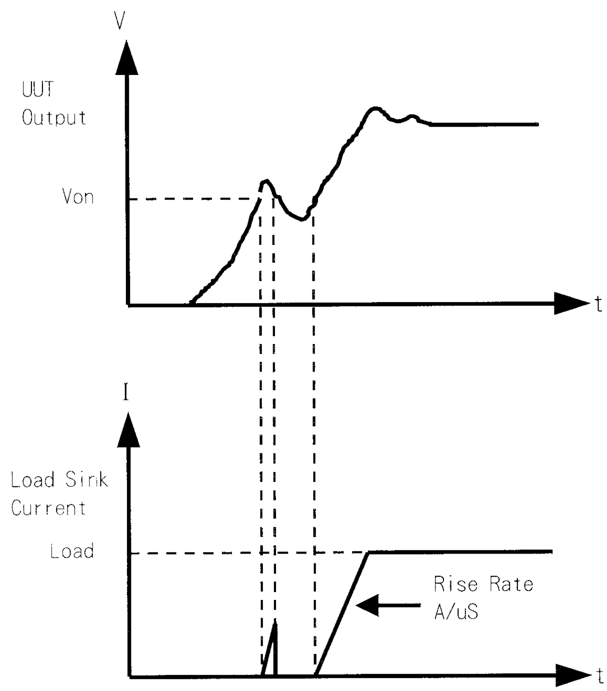


Figure 4-5 Von LATCH OFF Current Waveform

Set CV mode CURR_LIMIT. This function will limit the current sinking of Load to protect UUT in CV mode. The default setting of current limit is the maximum Load current.

```
CV CURR_LIMIT
CURRENT:20.000A
```

Set sign of voltage for display. The electronic Load will show a minus sign with the voltage if you select MINUS. The minus sign occupies one digit of the four digits displayed. No sign is displayed when you select PLUS. The default setting is PLUS.

```
SIGN OF VOLT.
1:PLUS 2:MINUS
```

Set the specifications of entry mode. The specifications of the Load can be set by VALUE or Percentage for HIGH and LOW data. The percentage values refer to the CENTER value of the specification. The default setting of SPEC entry mode is percentage.

```
SPEC. ENTRY MODE
1:VALUE 2:PCet
```

Set SYNChronous run mode. When SYNC run is set at ON, the Load on/off is controlled by the ON/OFF key on the Mainframe. Under other circumstances, the Load on/off is simply controlled by the LOAD key on the module. The default setting of SYNC run is ON.

```
SYNC. RUN
1:ON   2:OFF
```

Press ENTER to select data enter mode. If ON is selected for data entry, the setting will go to the next one after pressing ENTER. If OFF is selected for data entry, the setting will remain at the same line for additional changes. The default setting is ON.

```
Enter Data Next
1:ON   2:OFF
```

Select module SOUND on/off. When you press the key on the module, it will produce a sound if sound = ON. The default setting of sound is ON.

```
SOUND
1:ON   2:OFF
```

Select Load module input status when it is powered ON. If ON is selected, the module will be active according to AUTO LOADON mode setting. The default setting of AUTO LOADON is OFF.

```
AUTO LOADON
1:ON  2:OFF
```

Select the load on mode of module if AUTO LOADON is ON. If LOAD is selected, the Load module will be active as DEFAULT setting. If PROG is selected, the module will be active as the program saved last time. The default setting of AUTO LOADON MODE is LOAD.

```
AUTO LOADON MODE
1:LOAD  2:PROG.
```

Select Load module rotary knob type. There are two types for you to change load module data with the rotary knob.

UPDATED means that the data changed by the rotary knob will be updated on the load module. When you press LOAD key to set load module ON, new data will be executed.

OLD means that the data changed by the rotary knob will be invalid and the load module data remain the same if the load module is ON again. For the operation of rotary knob, please refer to 4.3.1 and 4.3.2.

```
LOADON KNOB TYPE
1=UPDATED  2=OLD
```

Select short key mode. Set SHORT key mode for Load module. The default setting of SHORT mode is TOGGLE.

```
SHORT
1:TOGGLE 2:HOLD
```

Display versions of load module and mainframe.

```
LOAD MODEL  80-20-102
Version:   10
```

Press the ▼ key.

```
FRAME BOOT PROG.
Version:   1.40
```

Press the ▼ key.

```
FRAME DOWN PROG.
Version:    1.21
```

Press the ▼ key.

```
FRAME EXEC PROG.
Version:    1.41
```

4.2.7 Recalling Files

Press RECALL to recall files from 1 to 101. Files 1 to 100 are user data. File 101 is factory set state. After a file is recalled, the display will go to the mode editor for you to edit or view the file. When you press RECALL, the display will show the file number last recalled. The default file number is 2 when the mainframe is powered on

Press RECALL, 3, then ENTER to recall the number 3.

```
RECALL FILE
FILE NO:    3
```

The data of all channels will be recalled when you execute file recall.

4.2.8 Saving Files

There are 100 file locations (1 to 100) for you to save files. Press SAVE, 2, 0, then ENTER to save a file to location 20.

```
SAVE FILE
FILE NO:  20
```

4.2.9 Saving Defaults

Press SAVE, and the ▼ key until the display shows as follows. The DEFAULT states are used for electronic Load after power-on. Press 1 to save DEFAULT to EEPROM.

```
SAVE DEFAULT
1:YES   2:NO
```

4.2.10 Saving Programs

Press SAVE, and the ▼ key until the display shows as follows. Press 1 to save program.

```
SAVE PROGRAM
1:YES   2:NO
```

4.2.11 Going To Local

The SHIFT key operates as a local key, LCL when electronic Load is in remote mode. You can press the LCL key to go to local operation when Load is in remote state. In local operation, SHIFT operates as the shift key.

4.2.12 Lock Operation

The lock operation disables any setting for change. When data are locked, no settings can change. The operation of ON/OFF and SPEC keys will not be affected by lock function. Press SHIFT and "." simultaneously to enable/disable lock function. This is a toggle key to enable/disable lock function.

4.2.13 Setting System and RS-232C Connection

The parameters of RS-232C are set in the system. There are three parameters for you to set:: Baud Rate, Parity Check, and Data Bit number. Press SHIFT and 0 simultaneously to set system data.

Baud Rate : 0:600, 1:1200, 2:2400, 3:4800, 4:9600 bits/second.
Parity Check : 0:EVEN, 1:ODD, 2:NONE.
Data Bit : 0:7 bits, 1:8 bits.

The RS-232C connector on the rear panel of Mainframe is a 9-pin connector (DB-9, male connector). The RS-232C connector bus signal is defined as follows.

PIN NO.	INPUT/OUTPUT	DESCRIPTION
1	Output	+5V
2	Input	R×D
3	Output	T×D
4	Output	DTR
5	Output	GND
6	Input	DSR
7	NC	—
8	NC	—
9	NC	—

NOTE: *Pin 1 (+5V) is for MML series Remote Controller only.*

Table 4-2 RS-232C Connector

4.2.14 Connecting the GO/NG Output Port

The GO/NG output port on the rear panel of Mainframe is a 15-pin connector (DB-15, female connector). The GO/NG signals are TTL active low to indicate NG. They are defined as follows.

PIN NO.	CHANNEL NO.	DESCRIPTION
1	1	H:PASS or SPEC. OFF, L:FAIL
3	2	H:PASS or SPEC. OFF, L:FAIL
5	3	H:PASS or SPEC. OFF, L:FAIL
7	4	H:PASS or SPEC. OFF, L:FAIL
9	5	H:PASS or SPEC. OFF, L:FAIL
11	6	H:PASS or SPEC. OFF, L:FAIL
13	7	H:PASS or SPEC. OFF, L:FAIL
15	8	H:PASS or SPEC. OFF, L:FAIL
8	Enable	H:SPEC. OFF, L:SPEC. ON

NOTE: *Pin 2, 4, 6, 10, 12, 14 are connected to GND.*

Table 4-3 GO/NG Output Port Connector

4.2.15 Setting the GPIB Address

GPIB address displays after RS-232C parameters in the system. You can use this feature to check GPIB address.

```
GPIB ADDRESS 1
```

4.3 Local Operation of Load Module

There are two kinds of panels in Load module. One is a single channel/module panel. The other is a double channels/module panel. There are four keys for each of the module panels. Only one key is different from these keypads. Figure 4-6 shows the single channel/module front panel.

4.3.1 Local Operation of Single Channel/Module (Panel A)

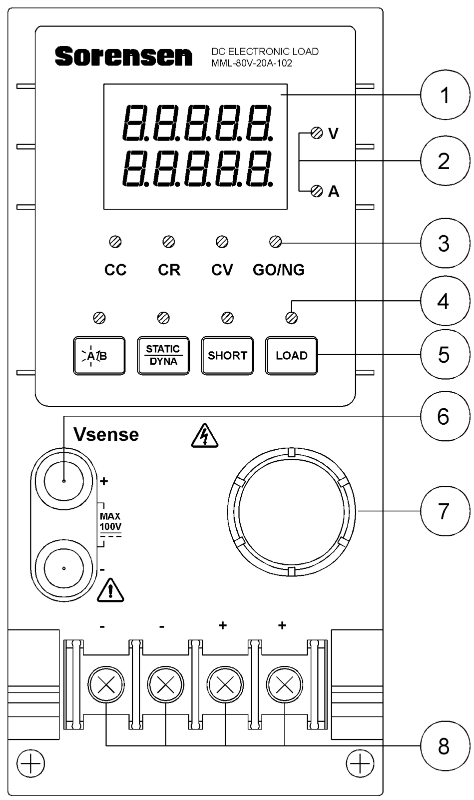


Figure 4-6 Single Channel/Module (Panel A)

① **7-segment LED Display.** Displays the measurement Voltage and Current. Each display has five digits.

② **7-segment Display Unit Indicators.** Indicates the 7-segment display measurement unit V and I.

③ **Operation Mode and GO/NG indicators.** Indicates the operation modes of CC, CR, CV, and GO/NG in the Load module. GO/NG LED indicator has two color. The green LED is on for GO (pass) while the red for NG (fail). The GO/NG LED is off when SPEC test is OFF.

④ **Keypad Indicators.** The four LEDs indicate the keypad status. Each LED shows the key status under the LED. Refer to the next paragraph for LED on/off status.

⑤ **Keypad.** There are four keys for you to select/control the operation of Load module. The A/B key is used to select static load level. Its LED will be on when the Load is in level1(A) state and off when in level2(B) state or others. The A/B key can be used to select Fix mode for rotary knob setting too. Please refer to 4.3.3.

The STATIC/DYNA key selects STATIC/DYNAmic mode. Its LED will be on when the Load is in DYNAmic mode. DYNAmic operation is only effective in CC mode. In other modes, this key has no response.

The SHORT key enables Load to simulate short function. Its LED will be on when the short function of Load is enabled. It operates only when the Load input is enabled. It will not respond if Load input is not enabled.

The LOAD key controls the on/off of the Load module input. Its LED will be on when the Load input is enabled.

⑥ **Vsense Connectors.** These two connectors are Vsense measurement input. Refer to 2.5.2 for remote sense connections.

⑦ **Rotary Knob.** The knob changes the level when the Load input is enabled. Rotating the knob clockwise will increase level whereas counterclockwise decrease level. When you change Load level with the knob, the setting of Mainframe will not change. The changed Load level will hold unless the same setting is changed on Mainframe.

⑧ **Load Terminals.** They are input connectors of the Load for connecting to the UUT. Each of them carries a maximum of 40 Amps. If the current is over 40 Amps, you must connect two or more terminals for load connection. The PLUS (+) must be connected to the high potential of UUT. Refer to 2.5.1 for load input connection.

Examples

The following examples illustrate how to operate the module in CC mode.

1. Select Level1 (A) and Level2 (B)

There are two levels of each mode for you to select in static function. The level1 (A) and level2 (B) can be selected through A/B key. Press A/B key to select current level1 or level2. When level1 (A) is selected, the LED of A/B key will be active. Press this key again to select level2 (B), and the LED will be inactive.

2. Select Dynamic Function

There are two functions for CC mode: STATIC and DYNAmic. The two functions can be selected through STATIC/DYNA key. Press STATIC/DYNA key to select Dynamic function. Press this key again to select static function. When Dynamic function is selected, the LED of DYNA will be active.

3. Short the Load Input

The Load can simulate a short circuit across the input. The short circuit will be enabled when SHORT is pressed, and Load input is active (on). If the input is shorted, the LED of short will be active. The SHORT key can be set in configuration of toggled on/off mode, or active by pressing mode.

4. Load Input On/Off

The input can be toggled on or off by pressing LOAD. When the input is turned on, the LED of load will be active.

4.3.2 Local Operation of Double Channels/Module (Panel B)

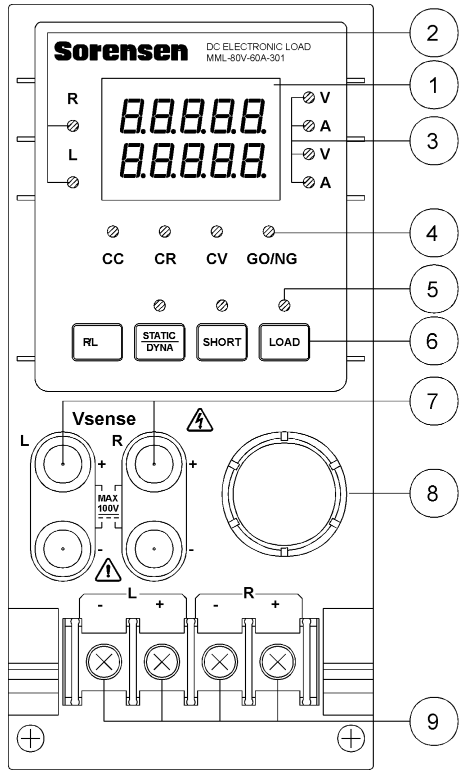


Figure 4-7 Double Channels/Module (Panel B)

The double channels/module means that there are two channels for one module. Each channel of module is isolated from the other. One set of display/keypad for the module can control both channels. The left channel is called channel L while the right one channel R. The 7-segment LED displays one or two channel status. The keypad and rotary knob can control both channels through R/L key.

① **7-segment LED Display**. Displays measurement V/I of single or double channels. Each display has five digits.

② **Channel LED Indicators.** There are two LEDs to indicate the active right and/or left channel(s) of the Load module. When the LED of channel R is on, the 7-segment display, mode, GO/NG indicators, and keypad are active on channel R. Channel L functions the same as channel R when its LED indicator is on.

When the indicators of channel R and L are on, the 7-segment display selectively shows both channels' V or I. The indicators and STATIC/DYNA, SHORT, and LOAD keys in operation mode will be disabled when both channels are selected.

③ **7-segment Display Unit Indicators.** Indicate the 7-segment display measurement unit V and/or I.

④ **Operation Mode and GO/NG Indicators.** When the LED of channel R or L is on, the operation and GO/NG LED have the same function as single channel/module. When the LEDs of channel R and L are on, the LED of operation mode indicators will be disabled (off). The GO/NG LED will be red when the check of any channel SPEC fails. It will be green when the check of both channels SPEC is all right.

⑤ **Keypad Indicators.** There are three LEDs indicating the keypad status. Each LED shows the key status. It has the same function as single channel/module. The LED of LOAD will be active when any input of channel L or R is on.

⑥ **Keypad.** There are four keys for you to select/control the operation of Load module. The R/L key is used to select the display of 7-segment LED, and the indicators of channel R and/or L. The R/L key can be used to select Fix mode for rotary knob setting too. Please refer to 4.3.3.

⑦ **Vsense Connectors.** These four connectors are for Vsense measurement input. The two connectors on the right are for right channel while those on the left for left channel. Refer to 2.5.2 for remote sensing connections.

⑧ **Rotary Knob.** The knob has the same function as single channel/module when channel R or L is selected. If the indicators of channel R and L are on, the knob will be disabled.

⑨ **Load Terminals.** They are input connectors of the Load for connecting to the UUT. The two terminals on the left are for input of left channel while those on the right for that of right channel. The PLUS (+) sign of the input of each channel must connect the high potential. Refer to 2.5.1 for load input connections.

Examples

The following examples illustrate how to select the double channels/module in CC mode.

There are two channels/modules, so you have to select right or left channel for display and keypad. When channel R and L are selected, only the R/L key is enabled; other keys are disabled. During power-on, the preselected channel is channel L. It means that the 7-segment display, indicators, and keypad are active at channel L. The double channels/module has the same function as single channel/module. However, level 2(B) cannot be selected.

1. The display sequence of R/L key is channel L -> channel R -> channels L+R display V -> channels L+R I back to channel L.

2. Select Dynamic Function
The static and dynamic function can be selected through the STATIC/DYNA key. Press this key to select Dynamic function, and press again to select static function. When Dynamic function is selected, the LED of DYNAmic will be active.

3. Short the Load Input
The Load can simulate a short circuit across the input. The short circuit can be enabled when SHORT is pressed, and Load input is active. When the input is shorted, the LED of short will be active. The SHORT key can be set in configuration of toggled on/off mode, or active by pressing mode.

4. Load Input On/Off
The input can be toggled on or off by pressing LOAD. When the input is turned on, the LED of LOAD will be active.

4.3.3 Online Change Level

The Load module provides you with two ways of online change level. They are convenient for you to change the load directly with the rotary knob in LOADON. These two operation modes are described below.

Ratio Mode: In LOADON change load with the rotary knob.
When the rotary knob rotates clockwise, it means as follows.
CC mode: raise the current value.
CR mode: raise the resistance value.
CV mode: raise the voltage value.

When the rotary knob rotates counterclockwise, it means as follows.
CC mode: lower the current value.
CR mode: lower the resistance value.
CV mode: lower the voltage value.

The modulation is dependent on the rotating speed of the rotary knob.

Fixed Mode: In LOADON press the A/B key (single channel/module) or the R/L key (double channel/module) for at least 2.5 seconds to access this operation mode. Now V and I will be displayed in fixed positions in this mode. Press the A/B, R/L, or STATIC/DYNA key to shift a digit left or right. The resolution nearest that digit will begin to change. The changed digit will be displayed glisteningly, and modulated by the rotary knob. To exit from this mode, press the A/B or R/L key for at least 2.5 seconds.

NOTE*: The value of mainframe setting will not be changed if the setting is changed by the rotary knob. Therefore, when you change the value of setting with the rotary knob, the value of load module setting and that of mainframe setting will not be the same.*

5 REMOTE OPERATION

5.1 Introduction

This section describes how to program the MML series electronic load remotely from a GPIB controller or RS232C. The command set introduced here can be applied to all electronic loads of the MML series, including MML-80-20-102 and MML-80-60-301, equipped with optional GPIB cards or standard equipment, RS232C.

Either GPIB or RS232C can be used at one time; they cannot be used simultaneously. If GPIB is used first in remote control, RS232C will be disabled until the unit has been reset, and vice versa.

5.2 DIP Switches on the GPIB Card

5.2.1 GPIB Address

Each device connected to the GPIB interface is assigned a unique address to allow communication with the system controller. Before programming the electronic load remotely via a GPIB computer, you need to know the GPIB address.

Setting the GPIB address of an individual mainframe is done with an 8-bit DIP switch on a GPIB card at its rear panel. The five bits from A1 to A5 are GPIB address bits which provide addressing space from 0 to 30. For details, please refer to Figure 5-1 and Table 5-1.

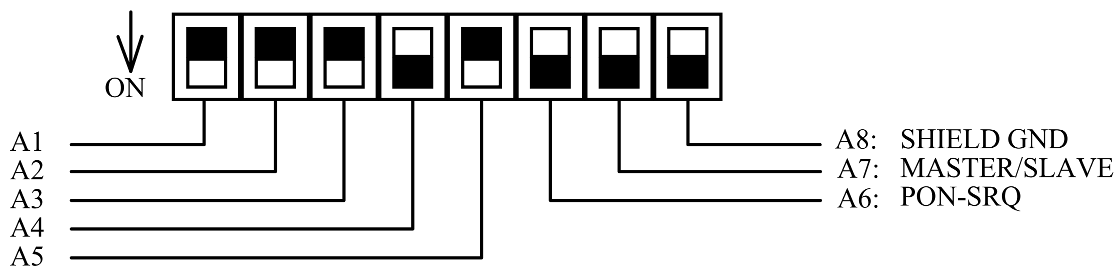


Figure 5-1 GPIB DIP Switch

Address	A5	A4	A3	A2	A1	Address	A5	A4	A3	A2	A1
0	0	0	0	0	0	16	1	0	0	0	0
1	0	0	0	0	1	17	1	0	0	0	1
2	0	0	0	1	0	18	1	0	0	1	0
3	0	0	0	1	1	19	1	0	0	1	1
4	0	0	1	0	0	20	1	0	1	0	0
5	0	0	1	0	1	21	1	0	1	0	1
6	0	0	1	1	0	22	1	0	1	1	0
7	0	0	1	1	1	23	1	0	1	1	1
8	0	1	0	0	0	24	1	1	0	0	0
9	0	1	0	0	1	25	1	1	0	0	1
10	0	1	0	1	0	26	1	1	0	1	0
11	0	1	0	1	1	27	1	1	0	1	1
12	0	1	1	0	0	28	1	1	1	0	0
13	0	1	1	0	1	29	1	1	1	0	1
14	0	1	1	1	0	30	1	1	1	1	0
15	0	1	1	1	1						

Table 5-1 GPIB Addresses

5.2.2 Other DIP Switches

The remaining bits on the DIP switch, A6-A8, preset the electronic load mainframe to the following functions:

Bit	Meaning	Preset	Description
A6	Frame LOAD ON Link	OFF	When ON is set, two frames can act as LOAD Key ON/OFF through RS232C port.
A7		OFF	It must be OFF.
A8	SHIELD GND	OFF	It is the selection for enabling shield ground.

5.3 GPIB Capability of the Electronic Load

GPIB Capability	Response	Interface Functions
Talker/ Listener	All electronic load functions except for setting the GPIB address are programmable over the GPIB. The electronic load can send and receive messages over the GPIB. Status information is sent using a serial poll.	AH1, SH1, T6, L4
Service Request	The electronic load will set the SRQ line true if there is an enabled service request condition.	SR1
Remote/ Local	In local mode, the electronic load is controlled from the front panel but will also execute commands sent over the GPIB. The electronic load powers up in local mode and remains there until it receives a command over the GPIB. Once the electronic load is in remote mode, *REMOTE* appears on the front panel LCD, all front panel keys except LCL are disabled, and the load module display is in normal metering mode. Pressing the LCL key on the front panel returns the electronic load to local mode. Local can be disabled using local lockout, so only the controller or the power switch can return the electronic load to local mode.	RL1
Device Clear	The electronic load responds to the Device Clear (DCL) and Selected Device Clear (SDC) interface commands. These cause the electronic load to clear any activity that may prevent it from receiving and executing a new command. DCL and SDC do not change any programmed settings.	DCL, SDC

5.4 RS232C in Remote Control

To enable remote control operation, send the command CONFigure: REMote ON. To return to local operation, send the command CONFigure: REMote OFF.

Terminate the RS232C command string with <nl>. Its ASCII code is hexadecimal 0A (or decimal 10). The control commands for RS232C are the same as those for GPIB.

5.5 Basic Programming Definitions

GPIB statements include instrument control and query commands. A command statement sends an instruction to the electronic load, and a query command requests information from the electronic load.

Simple Command
The simplest command statement consists of a command or keyword usually followed by a parameter or data:

LOAD ON
or TRIG

Compound Command
When two or more keywords are connected by colons (:), it creates a compound command statement. The last keyword usually is followed by a parameter or data:

CURRent: STATic: L1 3
or CONFigure: VOLTage: RANGe H

Query Command
A simple query command consists of a keyword followed by a question mark:

MEASure: VOLTage?
MEASure: CURRent?
or CHAN?

Forms of Keywords
Every keyword has two forms:

Long-Form. The word is spelled out completely to identify its function.
For instance, CURRENT, VOLTAGE, and MEASURE are long-form keywords.

Short-Form. The word contains only the first three or four letters of the long-form.
For instance, CURR, VOLT, and MEAS are short-form keywords.

In keyword definitions and diagrams, the short-form part of each keyword is emphasized in UPPER-CASE letters to help you remember it. However, the electronic load will accept Volt, volt, voltage, VOLTAGE, volTAGE, etc. without regard to which form you apply. If the keyword is incomplete, for example, “VOL” or “curre”, it will not be recognized.

5.6 Numerical Data Formats

The Sorensen MML Series electronic load accepts the numerical data types listed in Table 5-2.

Symbol	Description	Example
NR1	Digits with no decimal point. The decimal point is assumed to be to the right of the least-significant digit.	123, 0123
NR2	Digits with a decimal point.	123., 12.3, 0.123, .123
NR3	Digit with a decimal point and an exponent.	1.23E+3, 1.23E-3
NRf	Flexible decimal form that includes NR1 or NR2 or NR3.	123, 12.3, 1.23E+3
NRf+	Expanded decimal form that includes NRf and MIN, MAX. MIN and MAX are the minimum and maximum limit values for the parameter.	123, 12.3, 1.23E+3, MIN, MAX

Table 5-2 Numerical Data Type

Numerical data may be followed by a suffix that dimensions the data. A suffix may be preceded by a multiplier. The MML Series device makes use of the suffixes listed in Table 5-3 and multipliers listed in Table 5-4.

Mode	Class	Preferred Suffix	Secondary Suffix	Referenced Unit
CC	Current	A		Ampere
CR	Resistance	OHM		Ohm
CV	Amplitude	V		Volt
All	Time	S	MS	Second Millisecond
All	Slew Rate	A/µS		Amperes/Microsecond

Table 5-3 Suffix Elements

Multiplier	Mnemonic	Definition
1E6	MA	mega
1E3	K	kilo
1E-3	M	milli
1E-6	U	micro
1E-9	N	nano

Table 5-4 Suffix Multipliers

5.7 Character Data Formats

For command statements, the <NRf+> data format permits entry of required characters. For query statements, character strings may be returned in either of the forms shown in the following table. It depends on the length of the returned string.

Symbol	Character Form
crd	Character Response Data. They permit the return up to 12 characters.
aard	Arbitrary ASCII Response Data. They permit the return of undelimited 7-bit ASCII. This data type is an implied message terminator (refer to "Separators and Terminators").

5.8 Separators and Terminators

In addition to keywords and parameters, GPIB program statements require the following

Data Separators:

Data must be separated from the previous command keyword by a space. This is shown in examples as a space (CURR 3) and on diagrams by the letters *SP* inside a circle.

Keyword Separators:

Keywords (or headers) are separated by a colon (:), a semicolon(;), or both. For example:

- LOAD:SHOR ON
- MEAS:CURR?;VOLT?
- CURR:STAT:L1 3;:VOLT:L1 5

Program Line Separators:

A terminator informs GPIB that it has reached the end of a statement. Normally, this is sent automatically by your GPIB programming statements.

The termination also occurs with other terminator codes, such as EOI. In this manual, the terminator is assumed at the end of each example line of code. If it needs to be indicated, it is shown by the symbol <nl>, which stands for "new line" and represents the ASCII coded byte 0A hexadecimal (or 10 decimal).

Traversing the Command Tree:

- The colon (:) separates keywords from each other and represents changes in branch level to the next lower one. For example:

  CONF:VOLT:ON 5

  CONF is a root-level command, *VOLT* is the first branch, and *ON* is the second branch. Each colon moves down command interpretation to the next branch.

- The semicolon (;) allows you to combine command statements into one line. It returns the command interpretation to the previous colon. For example, you can combine the following two command statements:

  RES:RISE 100 <nl> and
  RES:L1 400 <nl>

  to form one command line as follows:

  RES:RISE 100;L1 400 <nl>

- To return to the root-level form you can:

  Enter a new-line character. This is symbolized by “<nl>” and can be linefeed “LF” or end-of-line “EOL.”

  or

  Enter a semicolon followed by a colon (;:).

  Note the following examples:

  1. (root):VOLT:L1: 30<nl>
     Starting a New Line returns to the Root.

  2. (root):SPEC:VOLT:H 30;
     :L 5;:

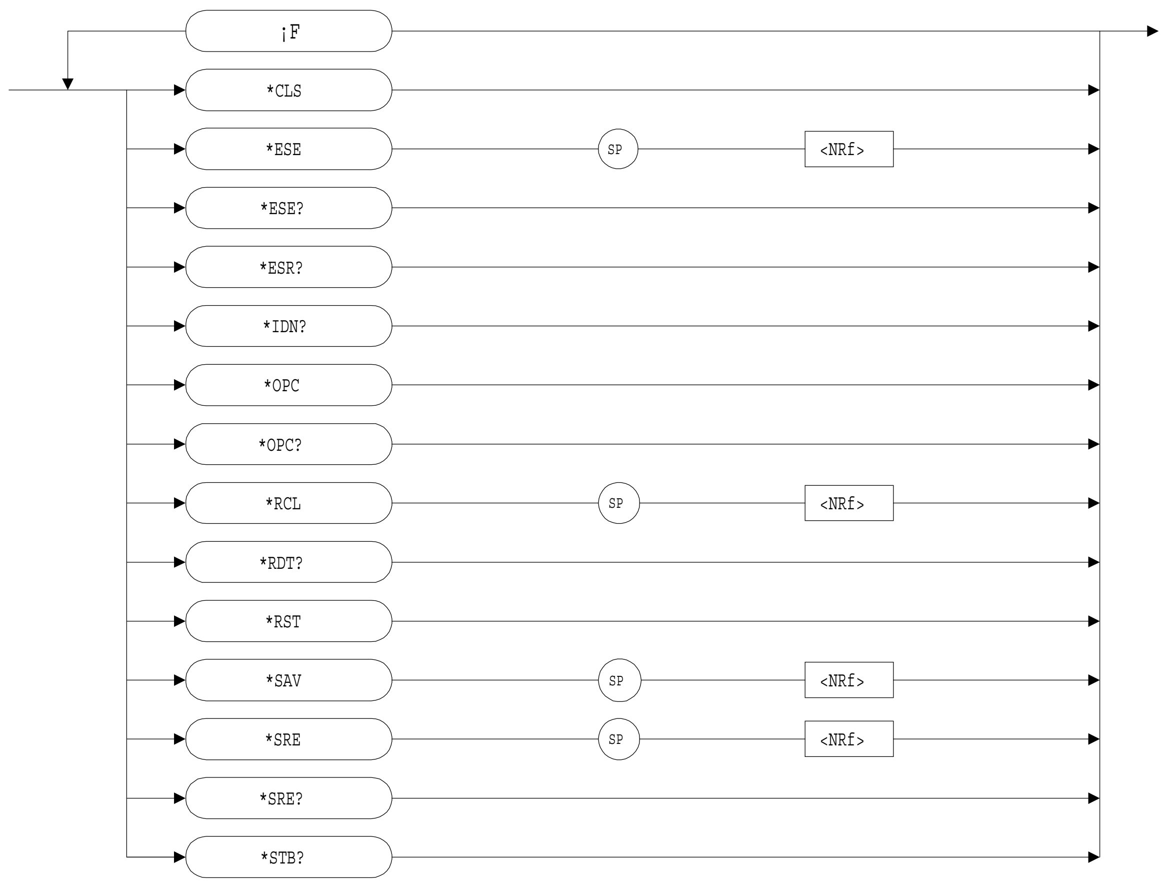
  3. (root):RES:L1 400;
     :RISE 1000;:

5.9 Language Dictionary

Commands for remote operation of the Electronic Load are grouped into subsystems. Subsystems are arranged in alphabetic order; commands within each subsystem are listed alphabetically. A syntax chart of the subsystem, which includes the commands belonging to the same group, is given.

5.9.1 Common Commands

Common commands defined by the IEEE488.2 standard are generic commands and queries. The first part of the language dictionary covers these commands. Each of them has a leading "*".



*CLS Clear Status Command

Type: Device Status

Description: The *CLS command executes the following actions:

1. Clear these registers
   - Channel Status Event registers for all channels
   - Channel Summary Event register
   - Questionable Status Event register
   - Standard Event Status Event register
   - Operation Status Event register
2. Clear the Error Queue
3. If "Clear Status Command" immediately follows a program message terminator (<nl>), the "Output Queue" and the MAV bit are also cleared.

Syntax: *CLS

Parameters: nil

*ESE Standard Event Status Enable Command/Query

Type: Device Status

Description: This command sets the condition of the Standard Event Status Enable register, which determines which events of the Standard Event Status Event register (see *ESR?are allowed to set the ESB (Event Summary Bit) of the Status Byte register. A "1" in the bit position enables the corresponding event. All of the enable events of the Standard Event Status Event register are logically ORed to cause the ESB (bit 5) of the Status Byte register to be set. See description of all three registers in Chapter 4, *Status Reporting*.

Syntax: *ESE <NRf>

Parameters: 0 to 255

Example: *ESE 48 — This command enables the CME and EXE events of the Standard Event Status Event register.

Query Syntax: *ESE?

Return Parameters: <NR1>

Query Example: *ESE? — This query returns current setting of "Standard Event Status Enable".

**ESR?   Standard Event Status Register Query*

Type: Device Status

Description: This query reads the Standard Event Status register. Reading the register clears it. See detailed explanation of this register in Chapter 4, *Status Reporting*.

Standard Event Status Event Register

Bit Position	7	6	5	4	3	2	1	0
Condition	0	0	CME	EXE	DDE	QYE	0	0
Bit Weight	128	64	32	16	8	4	2	1

Query Syntax: *ESR?

Return Parameters: <NR1>

Query Example: *ESR?   Returns status readings of Standard Event Status register.

Return Example: 48

**IDN?   Identification Query*

Type: System Interface

Description: This query requests the Electronic Frame (MML-4) to identify itself.

Query Syntax: *IDN?

Return Parameters: <aard>

Query Example: *IDN?

String	Information
Sorensen	Manufacturer
MML-4	Model
0	Always return zero
01.xx	Revision level of the primary interference firmware
0	Customer's version

Return Example: Sorensen MML-4,0,01.xx,0

**OPC   Operation Complete Command*

Type: Device Status

Description: This command causes the interface to set the OPC bit (bit 0) of the Standard Event Status register when the Electronic Frame (MML-4) has completed all pending operations.

Syntax: *OPC

Parameters: nil

*OPC?   Operation Complete Query

Type: Device Status

Description: This query returns an ASCII “1” when all pending operations are completed.

Query Syntax: *OPC?

Return Parameters: <NR1>

Query Example: 1

*RCL   Recall Instrument State Command

Type: Device Status

Description: This command restores the electronic load to a state that was previously stored in memory with the *SAV command to the specified location (see *SAV).

Syntax: *RCL <NRf>

Parameters: 1 to 101

Example: *RCL 50

*RDT?   Resource Description Transfer Query

Type: System Interface

Description: This command returns the types of Electronic Frame (MML-4). If channel does not exist, it returns 0. If channel exists, it returns the types such as MML-80-20-102.

Query Syntax: *RDT?

Return Parameters: <aard>

Query Example: 80802, 80802, 80802, 80802, 80802, 80802, 80802, 80802.

*RST   Reset Command

Type: Device State

Description: This command forces an ABORt, *CLS, LOAD=PROT=CLE command.

Syntax: *RST

Parameters: nil

*SAV   Save Command

Type: Device Status

Description: This command stores the present state of the single electronic load and the states of all channels of the multiple loads in a specified location in memory.

Syntax: *SAV <NRf>

Parameters: 1 to 100

Example: *SAV 50

*SRE Service Request Enable Command/Query

Type: Device Status

Description: This command sets the condition of the Service Request Enable register, which determines which events of the Status Byte register (see *STB) are allowed to set the MSS (Master Status Summary) bit. A "1" in the bit position enable bits are logically ORed to cause Bit 6 (the Master Summary Status Bit) of the Status Byte register to be set. See details concerning the Status Byte register in Chapter 4. *Status Reporting*.

Syntax: *SRE <NRf>

Parameters: 0 to 255

Example: *SRE 20 Enables the CSUM and MAV bit of the Service Request Enable.

Query Syntax: *SRE?

Return Parameters: <NR1>

Query Example: *SRE? Returns current setting for "Service Request Enable".

*STB? Read Status Byte Query

Type: Device Status

Description: This query reads the Status Byte register. Note that the MSS (Master Summary Status) bit instead of RQS bit is returned in Bit 6. This bit indicates if the electronic load has at least one reason for requesting service. *STB? does not clear the Status Byte register, which is cleared only when subsequent action has cleared all its set bits. Refer to Chapter 4, *Status Reporting* for more information about this register.

Status Byte Register

Bit Position	7	6	5	4	3	2	1	0
Condition	0	MSS	ESB	MAV	QUES	CSUM	0	0
Bit Weight	128	64	32	16	8	4	2	1

Query Syntax: *STB?

Return Parameters: <NR1>

Query Example: *STB? Returns the contents of "Status Byte."

Return Example: 20

5.10 Specific Commands

The MML series products are equipped with the following specific GPIB commands.

5.10.1 ABORT Subsystem

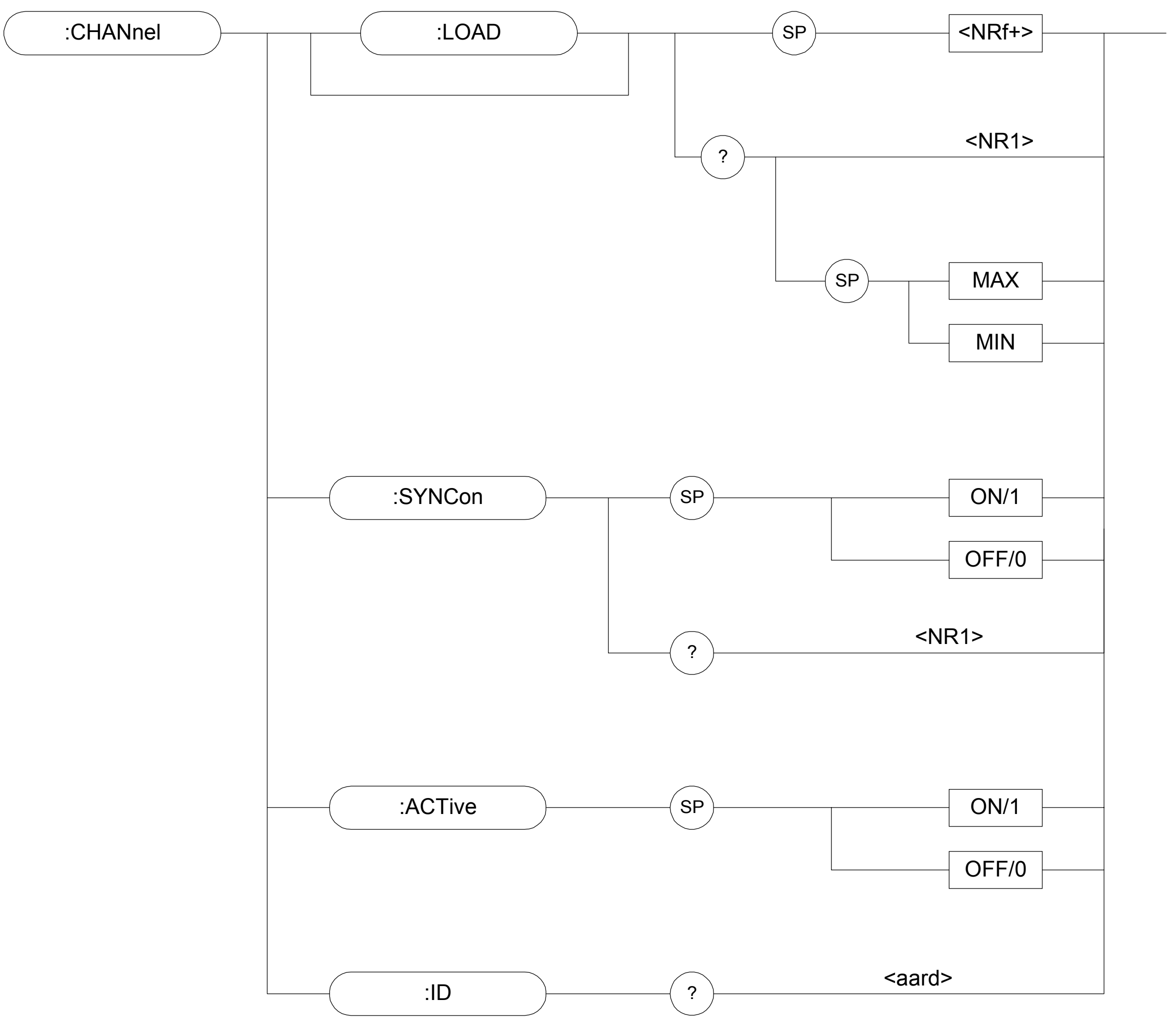
ABORt

Type: All Channel

Description: Sets all electronic loads as "OFF".

Syntax: ABORt

5.10.2 CHANNEL Subsystem



CHANnel:[LOAD]

Type:	Channel Specific	
Description:	Selects a specific channel by which the coming channel-specific command will be received and executed.	
Syntax:	CHANnel <NRf+>	
Parameters:	1 ~ 8	
Example:	CHAN 1	Sets specific channel as "1".
	CHAN MAX	Sets specific channel as "8".
	CHAN MIN	Sets specific channel as "1".
Query Syntax:	CHAN?	
	CHAN? MAX	
	CHAN? MIN	
Return Parameters:	<NR1>	
Query Example:	CHAN?	Returns current specific channel.
Return Example:	1	

CHANnel:ACTive

Type:	Channel Specific	
Description:	Enables or disables the load module.	
Syntax:	CHANnel : ACTive ON.	Enable the load module. The front panel displays the measurement of voltage and current.
	CHANnel : ACTive OFF.	Disable the load module. LCD on the front panel displays OFF.
Parameter:	ON/1, OFF/0	
Example:	CHAN : ACT ON	

CHANnel:SYNCon

Type:	Channel Specific	
Description:	Sets the load module to receive synchronized command action of RUN ABORT or not.	
Syntax:	CHANnel : SYNCon ON	
	CHANnel : SYNCon OFF	
Parameters:	ON/1, OFF/0	
Example:	CHAN : SYNC ON.	Sets the load module to receive synchronized command action.
	CHAN : SYNC OFF.	Sets the load module not to receive synchronized command action.
Query Syntax:	CHAN : SYNC?	

Return Parameters:	<NR1>	
Query Example:	CHAN : SYNC?	Returns to the load module and makes it receive synchronized command status.
Return Example:	0	The load module does not receive synchronized command status.
	1	The load module receives synchronized command status.

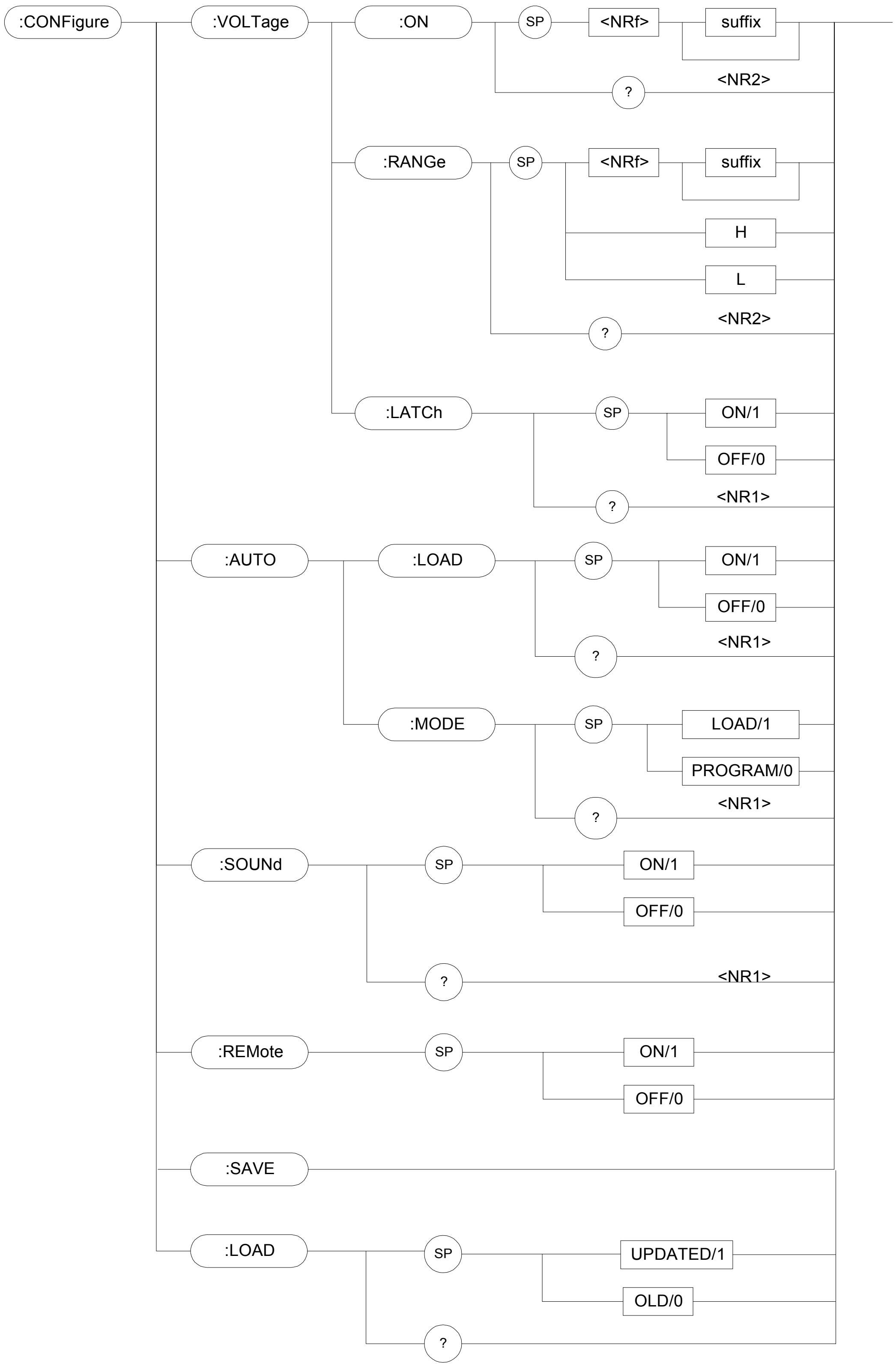
CHAN:ID?

Type:	Channel-specific
Description:	After going to a module, this query requests the module to identify itself.
Query Syntax:	ID?
Return Parameters:	<aard>
Query Example:	ID?

String	Information
Sorensen	Manufacturer
80202	Model (2 x 100W module)
0	Always return zero
01.08	Revision of the primary interface firmware
0	Customer's Version

Return Example: Sorensen,80202,0,01.08,0

5.10.3 CONFIGURE Subsystem



CONFigure:VOLTage:ON

Type:	Channel-specific	
Description:	Sets voltage of sink current on.	
Syntax:	CONFigure:VOLTage:ON <NRf> [suffix]	
Parameters:	For valid voltage range, refer to respective specification.	
Example:	CONF:VOLT:ON 1	Sets Von=1V.
	CONF:VOLT:ON 300mV	Sets Von=300mV.
Query Syntax:	CONFigure:VOLTage:ON?	
Return Parameters:	<NR2> [Unit=Voltage]	
Query Example:	CONF:VOLT:ON?	Returns setting Von value.
Return Example:	3.5	

CONFigure:VOLTage:RANGe

Type:	Channel-specific	
Description:	Sets voltage measurement range in CC mode.	
Syntax:	CONFigure:VOLTage:RANGEe <NRf> [suffix]	
Parameters:	Value ranges depend on Load Module. For details, refer to specification.	
Example:	CONF:VOLT:RANG 16	Sets full-range as Low, for example, in MML-80V-60A-301.
	CONF:VOLT:RANG 80V	Sets full-range as High, for example, in MML-80V-60A-301.
	CONF:VOLT:RANG H	Sets full-range as High.
	CONF:VOLT:RANG L	Sets full-range as Low.
Query Syntax:	CONFigure:VOLTage:RANGe?	
Return Parameters:	<NR2> [Unit = Voltage]	
Query Example:	CONF:VOLT:RANG?	Returns Voltage range.
Return Example:	16	

CONFigure:VOLTage:LATCh

Type:	Channel-specific	
Description:	Sets the action type of Von.	
Syntax:	CONFigure:VOLTage:LATch ON	
	CONFigure:VOLTage:LATch OFF	
Parameters:	ON/1, OFF/0	
Example:	CONF:VOLT:LAT ON	Sets the action type of Von as Latch.
	CONF:VOLT:LAT OFF	Sets the action type of Von as Non Latch (for details, see Section 4).
Query Syntax:	CONFigure:VOLTage:LATch?	
Return Parameters:	<NR1>	
Query Example:	CONF:VOLT:LAT?	
Return Example:	0 (non latch), 1 (latch)	Returns the action type of Von.

CONFigure:AUTO:LOAD

Type:	All Channel	
Description:	Sets if the load module will do Auto Load On during power-on.	
Syntax:	CONFigure:AUTO:LOAD ON	
	CONFigure:AUTO:LOAD OFF	
Parameters:	ON/1, OFF/0	
Example:	CONF:AUTO:LOAD ON	Starts Auto Load On during power-on.
	CONF:AUTO:LOAD OFF	Closes Auto Load On during power-on.
Query Syntax:	CONFigure:AUTO:LOAD?	
Return Parameters:	<NR1>	
Query Example:	CONF:AUTO:LOAD?	
Return Example:	0 or 1 Returns the status of Auto Load On	

CONFigure:AUTO:MODE

Type:	All Channel
Description:	Sets type of Auto Load On as LOAD ON or PROGRAM RUN.
Syntax:	CONFigure:AUTO:MODE LOAD
	CONFigure:AUTO:MODE PROGRAM
Parameters:	LOAD/1, PROGRAM/0

Example:	CONF:AUTO:MODE LOAD	Sets Auto Load On as general LOAD ON.
	CONF:AUTO:MODE PROGRAM	Sets Auto Load On as PROGRAM RUN.
Query Syntax:	CONFigure:AUTO:MODE?	
Return Parameters:	<NR1>	
Query Example:	CONF:AUTO:MODE?	Returns the execution
Return Example:	0 or 1 type of Auto Load On.	

CONFigure:SOUND

Type:	Channel-specific	
Description:	Sets the buffer sound of the load module as ON/OFF.	
Syntax:	CONFigure:SOUND ON	
	CONFigure:SOUND OFF	
Parameters:	ON/1, OFF/0	
Example:	CONF:SOUND ON	
	CONF:SOUND OFF	
Query Syntax:	CONFigure:SOUND?	
Return Parameters:	<NR1>	
Query Example:	CONF:SOUND?	Returns the control status of the load module's buzzer sound.
Return Example:	0 or 1	

CONFigure:REMote

Type:	All Channel	
Description:	Sets the status of remote control (only effective in RS232C).	
Syntax:	CONFigure:REMote ON	
	CONFigure:REMote OFF	
Parameters:	ON/1, OFF/0	
Example:	CONF:REM ON	Sets as remote control.

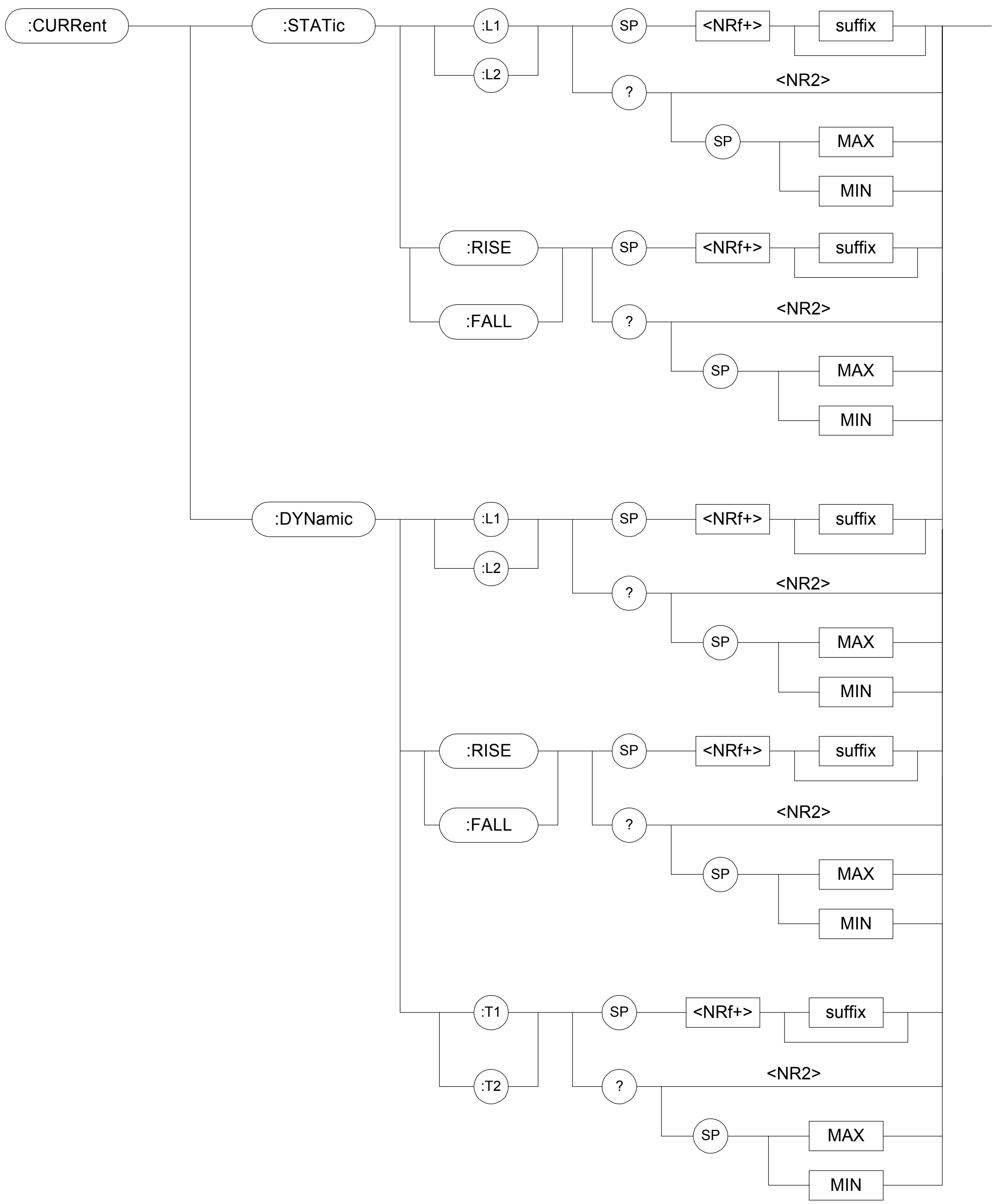
CONFigure:SAVE

Type:	All Channel
Description:	Stores the data of CONFigure into EEPROM.
Syntax:	CONFigure:SAVE
Parameters:	none
Example:	CONF:SAVE

CONFigure:LOAD

Type:	All Channel	
Description:	The value at the setting of load module as LOADON is the one changed by the rotary knob (UPDATED/1) or the original set value (OLD/0).	
Syntax:	CONFigure:LOAD UPDATED	
	CONFigure:LOAD OLD	
Parameters:	UPDATED/1, OLD/0	
Example:	CONF:LOAD UPDATED	Sets the value of LOADON as that changed by the rotary knob.
	CONF:LOAD OLD	Sets the value of LOADON as the original set value.
Query Syntax:	CONFigure:LOAD?	
Return Parameters:	<NR1>	
Query Example:	CONF:LOAD?	
Return Example:	1 (UPDATED) or 0 (OLD)	

5.10.4 CURRENT Subsystem



CURRent:STATic:L1/L2

Type:	Channel-specific	
Description:	Sets Static Load Current of constant current mode.	
Syntax:	CURRent:STATic:L1	<NRf+> [suffix]
	CURRent:STATic:L2	<NRf+> [suffix]
Parameters:	For valid value range, refer to respective specification.	
Example:	CURR:STAT:L1 20	Sets Constant Current = 20A for Static Load L1.
	CURR:STAT:L2 10	Sets Constant Current = 10A for Static Load L2.
	CURR:STAT:L1 MAX	Sets Constant Current = maximum value for Static Load L1.
	CURR:STAT:L2 MIN	Sets Constant Current = minimum value for Static Load L2.
Query Syntax:	CURRent:STATic:L1?	
	CURRent:STATic:L2?	
	CURRent:STATic:L1? MAX	
	CURRent:STATic:L2? MIN	
Return Parameters:	<NR2> [Unit=Ampere]	
Query Example:	CURR:STAT:L1?	Returns set current value of the Static Load L1.
Return Example:	3.12	

CURRent:STATic:RISE/FALL

Type:	Channel-specific	
Description:	Sets current slew rate of constant current static mode.	
Syntax:	CURRent:STATic:RISE <NRf+> [suffix]	
	CURRent:STATic:FALL <NRf+> [suffix]	
Parameters:	For valid value range, refer to respective specification.	
Example:	CURR:STAT:RISE 2.5	Sets rise slew rate as 2.5A/μS of static load.
	CURR:STAT:FALL 1A/μS	Sets fall slew rate as 1A/μS of static load.
Query Syntax:	CURRent:STATic:RISE?	
	CURRent:STATic:FALL?	
	CURRent:STATic:RISE? MAX	
	CURRent:STATic:FALL? MIN	
Return Parameters:	<NR2> [Unit=A/μS]	
Query Example:	CURR:STAT:RISE?	Returns rise slew rate of static load.
Return Example:	2.5	

CURRent:DYNamic:L1/L2

Type:	Channel-specific	
Description:	Sets Dynamic Load Current during constant current mode.	
Syntax:	CURRent:DYNamic:L1 <NRf+> [suffix]	
	CURRent:DYNamic:L2 <NRf+> [suffix]	
Parameters:	For valid value range, refer to respective specification.	
Example:	CURR:DYN:L1 20	Sets dynamic load parameter L1 = 20A.
	CURR:DYN:L2 10	Sets dynamic load parameter L2 = 10A.
	CURR:DYN:L1 MAX	Sets dynamic load parameter L1 = maximum value.
	CURR:DYN:L2 MIN	Sets dynamic load parameter L2 = minimum value.
Query Syntax:	CURRent:DYNamic:L1?	
	CURRent:DYNamic:L2?	
	CURRent:DYNamic:L1? MAX	
	CURRent:DYNamic:L2? MIN	
Return Parameters:	<NR2> [Unit=Ampere]	
Query Example:	CURR:DYN:L1?	Returns setting current in dynamic load L1.
Return Example:	35.6	

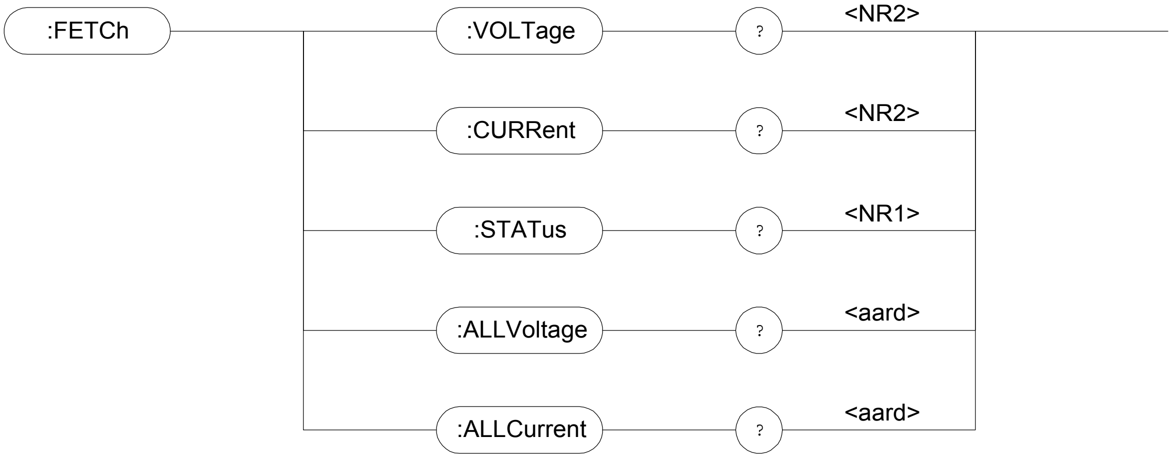
CURRent:DYNamic:RISE/FALL

Type:	Channel-specific
Description:	Sets current slew rate of constant current dynamic mode.
Syntax:	CURRent:DYNamic:RISE <NRf+> [suffix]
	CURRent:DYNamic:FALL <NRf+> [suffix]
Parameters:	For valid value range, refer to respective specification.
Example:	CURR:DYN:RISE 2.5 — Sets rise slew rate as 2.5A/µS.
	CURR:DYN:FALL 1A/µS — Sets fall slew rate as 1A/µS.
	CURR:DYN:RISE MAX — Sets rise slew rate as maximum value of dynamic load.
	CURR:DYN:FALL MIN — Sets fall slew rate as minimum value of dynamic load.
Query Syntax:	CURRent:DYNamic:RISE?
	CURRent:DYNamic:FALL?
	CURRent:DYNamic:RISE? MAX
	CURRent:DYNamic:FALL? MIN
Return Parameters:	<NR2> [Unit=A/µS]
Query Example:	CURR:DYN:RISE? — Returns rise slew rate of dynamic load.
Return Example:	2.5

CURRent:DYNamic:T1/T2

Type:	Channel-specific
Description:	Sets duration parameter T1 or T2 of dynamic load.
Syntax:	CURRent:DYNamic:T1 <NRf+> [suffix]
	CURRent:DYNamic:T2 <NRf+> [suffix]
Parameters:	For valid value range, refer to respective specification.
Example:	CURR:DYN:T1 10mS — Sets dynamic duration T1 = 10mS.
	CURR:DYN:T2 2S — Sets dynamic duration T2 = 2S.
	CURR:DYN:T1 MAX — Sets dynamic duration T1 as maximum value.
	CURR:DYN:T2 MIN — Sets dynamic duration T2 as minimum value.
Query Syntax:	CURRent:DYNamic:T1?
	CURRent:DYNamic:T2?
	CURRent:DYNamic:T1? MAX
	CURRent:DYNamic:T2? MIN
Return Parameters:	<NR2> [Unit=Sec]
Query Example:	CURR:DYN:T1? — Returns the dynamic duration parameter T1.
Return Example:	0.15

5.10.5 FETCH Subsystem



FETCh:VOLTage?

Type:	Channel-specific
Description:	Returns real time voltage measured at the input of the load module.
Query Syntax:	FETCh:VOLTage?
Return Parameters:	<NR2> [Unit=Voltage]
Query Example:	FETC:VOLT?
Return Example:	8.12

FETCh:CURRent?

Type:	Channel-specific
Description:	Returns real time current measured at the input of the load module.
Query Syntax:	FETCh:CURRent?
Return Parameters:	<NR2> [Unit=Amper]
Query Example:	FETC:CURR?
Return Example:	3.15

FETCh:STATus?

Type:	Channel-specific
Description:	Returns real time status of the load module.
Query Syntax:	FETCh:STATus?
Return Parameters:	<NR1>

FETCh:ALLVoltage?

Type: Channel-independent

Description: Returns real time voltage measured at the input of the all load module.

Query Syntax: FETCh:ALLVoltage?

Return Parameters: <aard> [Unit=Voltage]

Query Example: FETC:ALLV?

Return Example: 1.2, 2, 0, 0, 10.2, 0, 0, 0

FETCh:ALLCurrent?

Type: Channel-independent

Description: Returns real time current measured at the input of the all load module.

Query Syntax: FETCh:ALLCurrent?

Return Parameters: <aard> [Unit=Amper]

Query Example: FETC:ALLC?

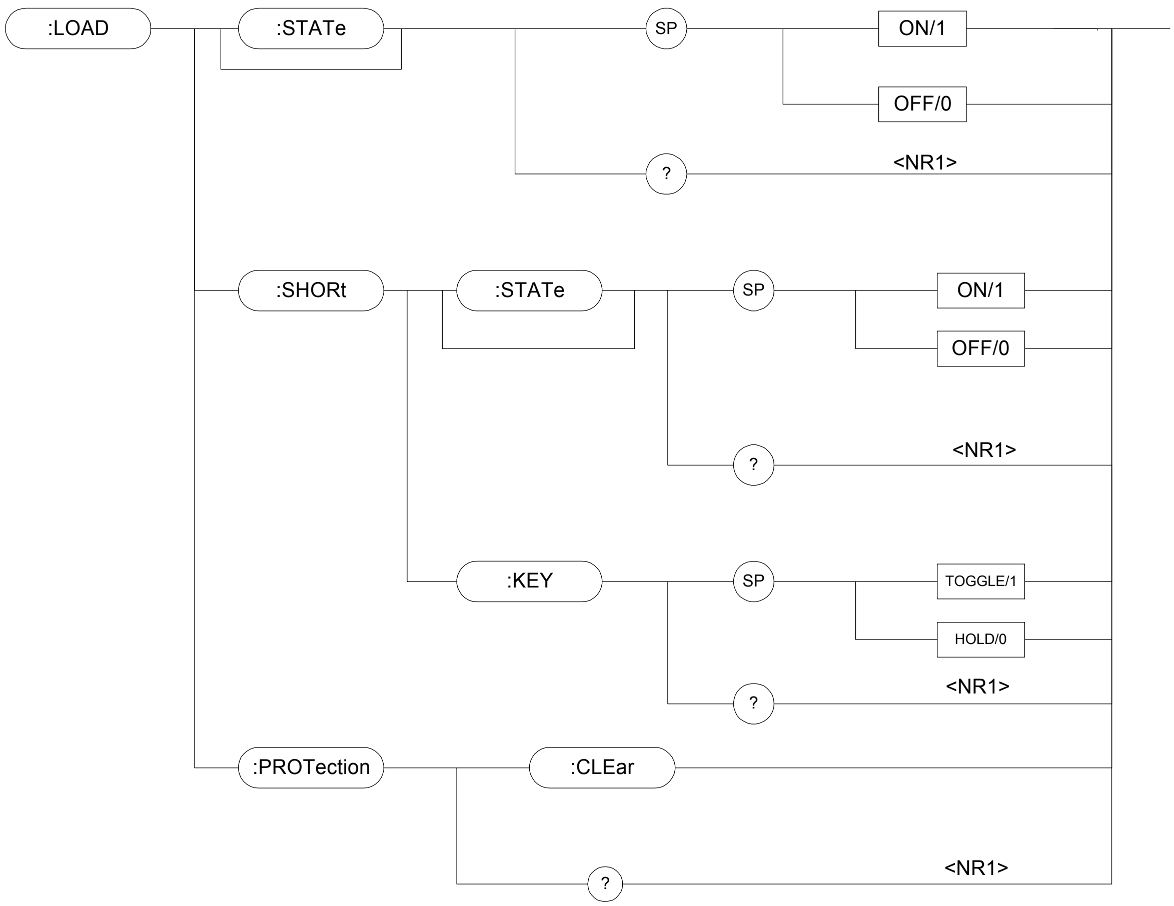
Return Example: 0, 0, 0, 0, 5.12, 0, 12, 0

Bit Position	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Condition												OT	RV	OP	OV	OC
Bit Weight												16	8	4	2	1

Query Example: FETC:STAT? Reads back the present status of load module.

Return Example: 4

5.10.6 LOAD Subsystem



LOAD:[STATe]

Type:	Channel-specific	
Description:	The LOAD command makes the electronic load active/on or inactive/off.	
Syntax:	LOAD:[STATe] ON	
	LOAD:[STATe] OFF	
Parameters:	ON/1, OFF/0	
Example:	LOAD ON	Activates the electronic load.
	LOAD OFF	Inactivates the electronic load.
Query Syntax:	LOAD:[STATe]?	
Return Parameters:	<NR1>	
Query Example:	LOAD?	Returns if the electronic load is active.
Return Example:	1	

LOAD:SHORt:[STATe]

Type:	Channel-specific	
Description:	Activate or inactivate short-circuited simulation.	
Syntax:	LOAD:SHORt:[STATe]	
Example:	LOAD:SHOR ON	Activates short-circuited simulation.
	LOAD:SHOR OFF	Inactivates short-circuited simulation.
Parameters:	ON/1, OFF/0	
Query Syntax:	LOAD:SHORt:[STATe]?	
Return Parameters:	<NR1>	
Query Example:	LOAD:SHOR?	Returns the short-circuited simulation state.
Return Example:	1	

LOAD:SHORt:KEY

Type:	Channel-specific	
Description:	Sets the mode of short key in the electronic load.	
Syntax:	LOAD:SHORt:KEY TOGGLE	
Parameters:	TOGGLE/1, HOLD/0	
Example:	LOAD:SHOR:KEY TOGGLE	Sets short key mode as Toggle.
	LOAD:SHOR:KEY HOLD	Sets short key mode as Hold.
Query Syntax:	LOAD:SHORt:KEY?	
Return Parameters:	<NR1>	
Query Example:	LOAD:SHOR:KEY?	Returns the mode of short key in the electronic load.
Return Example:	1	

LOAD:PROTection:CLEar

Type: Channel-specific

Description: This command resets or returns status of the electronic load.

Syntax: LOAD:PROTection:CLEar

Parameters: For valid value range, refer to respective specification.

Example: LOAD:PROT:CLE

Query Syntax: LOAD:PROTection:CLEar?

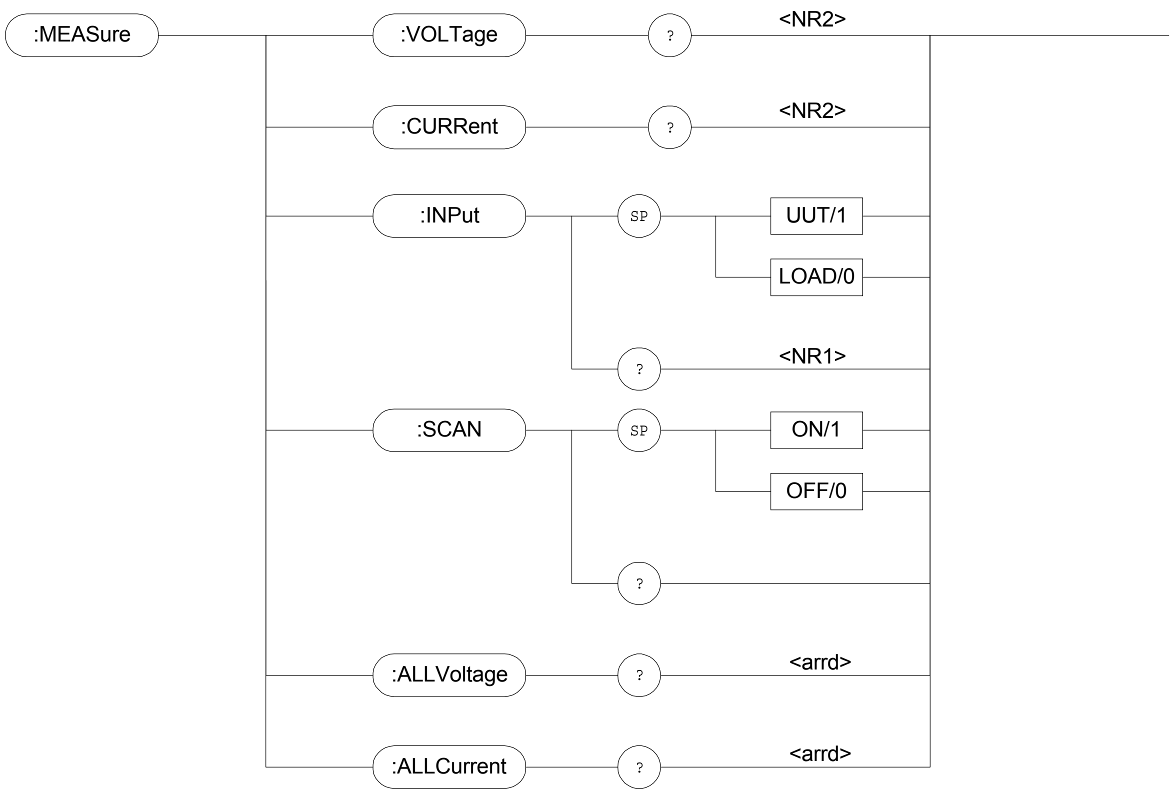
Return Parameters: <NR1>

Bit Position	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Condition	0	0	0	0	0	0	0	0	0	0	0	OT	RV	OP	OV	OC
Bit Weight												16	8	4	2	1

Query Example: LOAD:PROT? Returns status of the electronic load.

Return Example: 0

5.10.7 MEASURE Subsystem



MEASure:VOLTage?

Type:	Channel-specific
Description:	Returns voltage measured at the input of the electronic load.
Query Syntax:	MEASure:VOLTage?
Return Parameters:	<NR2> [Unit=Voltge]
Query Example:	MEAS:VOLT?
Return Example:	8.12

MEASure:CURRent?

Type:	Channel-specific
Description:	Returns current measured at the input of the electronic load.
Query Syntax:	MEASure:CURRent?
Return Parameters:	<NR2> [Unit=Amper]
Query Example:	MEAS:CURR?
Return Example:	3.15

MEASure:INPut

Type:	Channel-specific	
Description:	Selects the input port of the electronic load to measure voltage.	
Syntax:	MEASure:INPut?	
Parameters:	UUT/1, LOAD/0	
Example:	MEAS:INP UUT MEAS:INP LOAD	
Query Syntax:	MEASure:INPut?	Returns the input port which has been set.
Return Parameters:	<NR1>	
Query Example:	MEAS:INP?	
Return Example:	0	

MEASure:SCAN

Type:	All Channel	
Description:	Sets the scanning mode of frame to load module.	
Syntax:	MEASure:SCAN ON	Enables the frame to scan the load module.
	MEASure:SCAN OFF	Disables the frame to scan the load module.
Parameters:	ON/1, OFF/0	
Example:	MEAS:SCAN ON	
	MEAS:SCAN OFF	
Query Syntax:	MEASure:SCAN?	Returns the scanning mode of the frame.
Return Parameters:	<NR1>	
Query Example:	MEAS:SCAN?	
Return Example:	1	

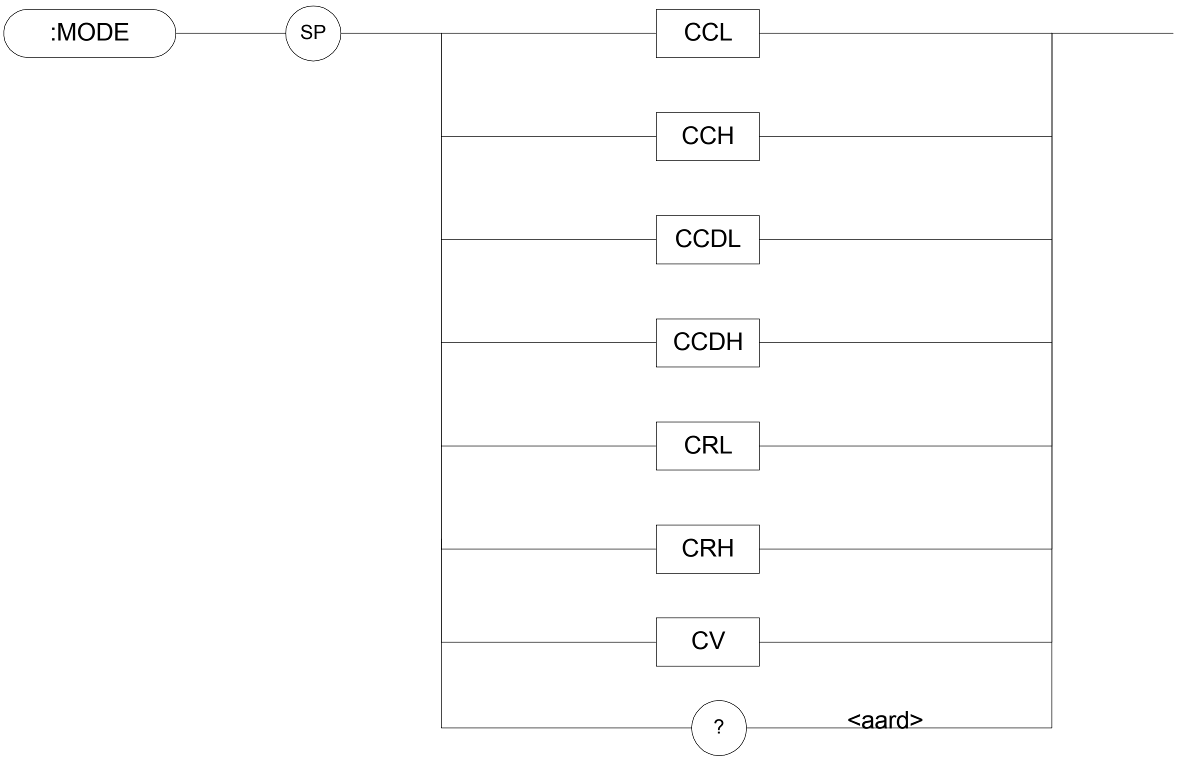
MEASure:ALLVoltage?

Type:	Channel-independent
Description:	Returns voltage measured at the input of the all load module.
Query Syntax:	MEASure:ALLVoltage?
Return Parameters:	<aard> [Unit=Voltage]
Query Example:	MEAS:ALLV?
Return Example:	1.2, 2, 0, 0, 10.2, 0, 0, 0

MEASure:ALLCurrent?

Type:	Channel-independent
Description:	Returns current measured at the input of the all load module.
Query Syntax:	MEASure:ALLCurrent?
Return Parameters:	<aard> [Unit=Amper]
Query Example:	MEAS:ALLC?
Return Example:	0, 0, 0, 0, 5.12, 0, 12, 0

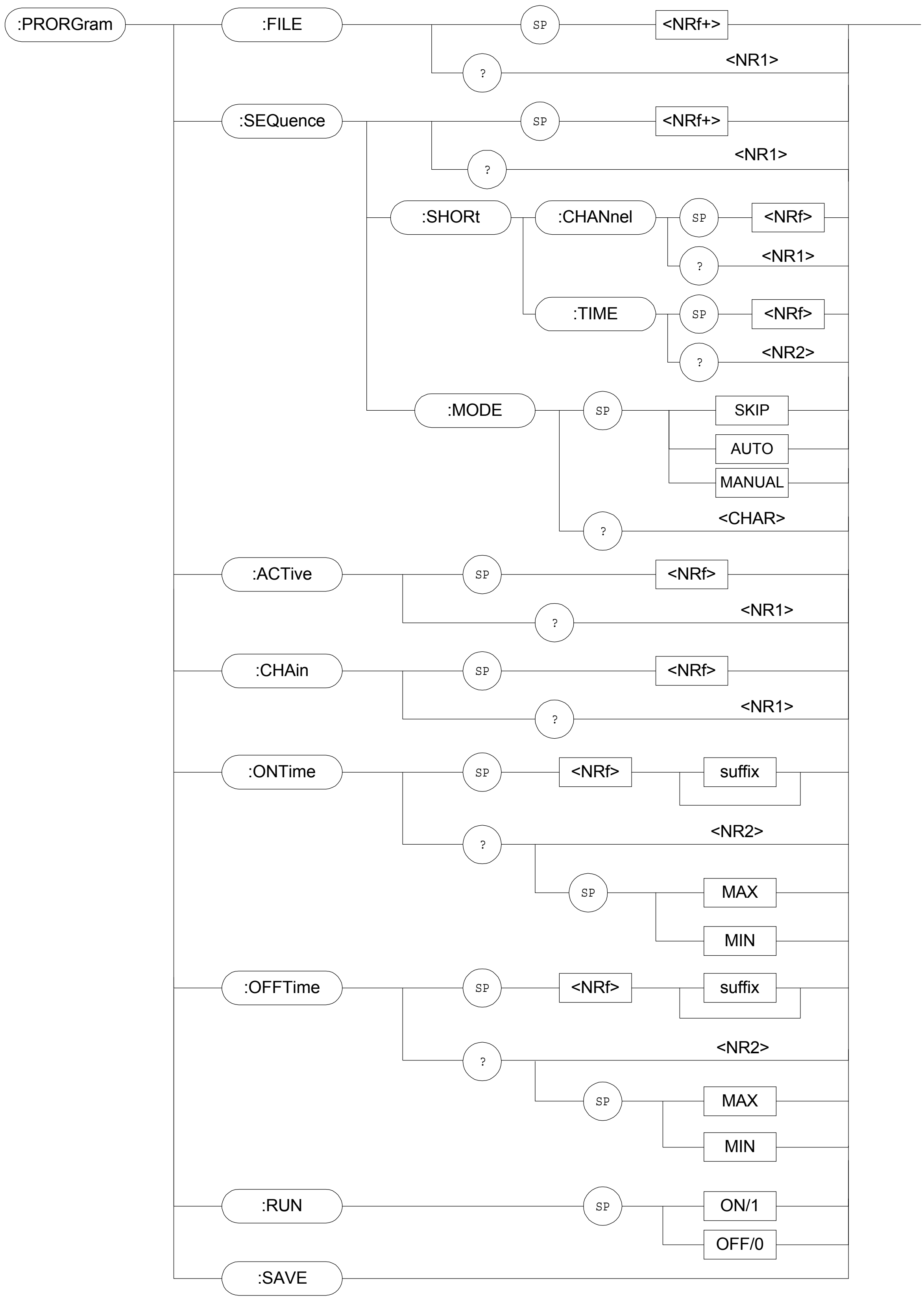
5.10.8 MODE Subsystem



MODE

Type:	Channel-specific	
Description:	This command sets operational modes of the electronic load.	
Syntax:	MODE CCL	Sets CC mode of low range.
	MODE CCH	Sets CC mode of high range.
	MODE CCDL	Sets CC dynamic mode of low range.
	MODE CCDH	Sets CC dynamic mode of high range.
	MODE CRL	Sets CR mode of low range.
	MODE CRH	Sets CR mode of high range.
	MODE CV	Sets CV mode.
Parameters:	CCL, CCH, CCDL, CCDH, CRL, CRH, CV	
Example:	MODE CCL	
Query Syntax:	MODE?	Returns the operational mode of the electronic load.
Return Parameters:	<aard>	
Query Example:	MODE?	
Return Example:	CCL	

5.10.9 PROGRAM Subsystem



PROGram:FILE

Type:	By program file
Description:	Sets the program number.
Syntax:	PROGram:FILE <NRf+>
Parameters:	1 to 10
Example:	PROG:FILE 10
Query Syntax:	PROGram:FILE? Returns the active program number.
Return Parameters:	<NR1>
Query Example:	PROG:FILE?
Return Example:	10

PROGram:SEQuency

Type:	By program file
Description:	Sets the sequency of program file.
Syntax:	PROGram:SEQuency <NRf+>
Parameters:	1 to 10
Example:	PROG:SEQ3
Query Syntax:	PROGram:SEQuency?
Return Parameters:	<NR1>
Query Example:	PROG:SEQ?
Return Example:	3

PROGram:SEQuency:MODE

Type:	By program file
Description:	Sets the type of sequency.
Syntax:	PROGram:SEQuency:MODE SKIP PROGram:SEQuency:MODE AUTO PROGram:SEQuency:MODE MANUAL
Parameters:	SKIP, AUTO, MANUAL
Example:	PROG:SEQ:MODE SKIP PROG:SEQ:MODE AUTO PROG:SEQ:MODE MANUAL
Query Syntax:	PROGram:SEQ:MODE?
Return Parameters:	SKIP, AUTO, MANUAL
Query Example:	PROG:SEQ:MODE?
Return Example:	AUTO

PROGram:SEQuency:SHORt:CHANnel

Type: By program file

Description: Sets the short channel of PROGRAM file SEQuency

Syntax: PROGram:SEQuency:SHORt:CHANnel <NRf>

Parameters: 0 - 255

Channel	8	7	6	5	4	3	2	1
Bit Weight	128	64	32	16	8	4	2	1

Example: PROG:SEQ:SHOR:CHAN 3

Query Syntax: PROGram:SEQuency:SHORt:CHANnel?

Return Parameter: <NR1>

Query Example: PROG:SEQ:SHOR:CHAN?

Return Example: 3

PROGram:SEQuency:SHORt:TIME

Type: By program file

Description: Sets the short time of PROGRAM file SEQuency.

Syntax: PROGram:SEQuency:SHORt:TIME

Parameters: 0 - 30.0

Example: PROG:SEQ:SHOR: TIME 10

Query Syntax: PROGram:SEQuency:SHORt:TIME?

Return Parameter: <NR2>

Query Example: PROG:SEQ:SHOR:TIME?

Return Example: 10

PROGram:ACTive

Type: By program file

Description: Selects the active load modules.

Syntax: PROGram:ACTive <NRf>

Parameters: 0 - 255

Channel	8	7	6	5	4	3	2	1
Bit Weight	128	64	32	16	8	4	2	1

Example: PROG:ACT 12

Query Syntax: PROGram:ACTive?

Return Parameters: <NR1>

Query Example: PROG:ACT?

Return Example: 12

PROGram:CHAin

Type:	By program file
Description:	Sets the type of program file in serial execution.
Syntax:	PROGram:CHAin <NRf>
Parameters:	0 to 10 0 does not chain.
Example:	PROG:CHA 7
Query Syntax:	PROGram:CHAin?
Return Parameters:	<NR1>
Query Example:	PROG:CHA?
Return Example:	7

PROGram:ONTime

Type:	By program file
Description:	Sets the load on time of program file.
Syntax:	PROGram:ONTime <NRf>
Parameters:	For valid value range, refer to respective sepcification.
Example:	PROG:ONT 10 PROG:ONT 100mS
Query Syntax:	PROGram:ONTime?
Return Parameters:	<NR2> [Unit=Sec]
Query Example:	PROG:ONT?
Return Example:	10

PROGram:OFFTime

Type:	By program file
Description:	Sets the load off time of program file.
Syntax:	PROGram:OFFTime <NRf>
Parameters:	For valid value range, refer to respective sepcification.
Example:	PROG:OFFT 20 PROG:OFFT 200mS
Query Syntax:	PROGram:OFFTime?
Return Parameters:	<NR2> [Unit=Sec]
Query Example:	PROG:OFFT?
Return Example:	0.2

PROGram:RUN

Type: By program file

Description: Executes program run according to the set program file.

Syntax: PROGram:RUN ON

PROGram:RUN OFF

Parameters: ON/1, OFF/0

Example: PROG:RUN ON

PROGram:SAVE

Type: By program file

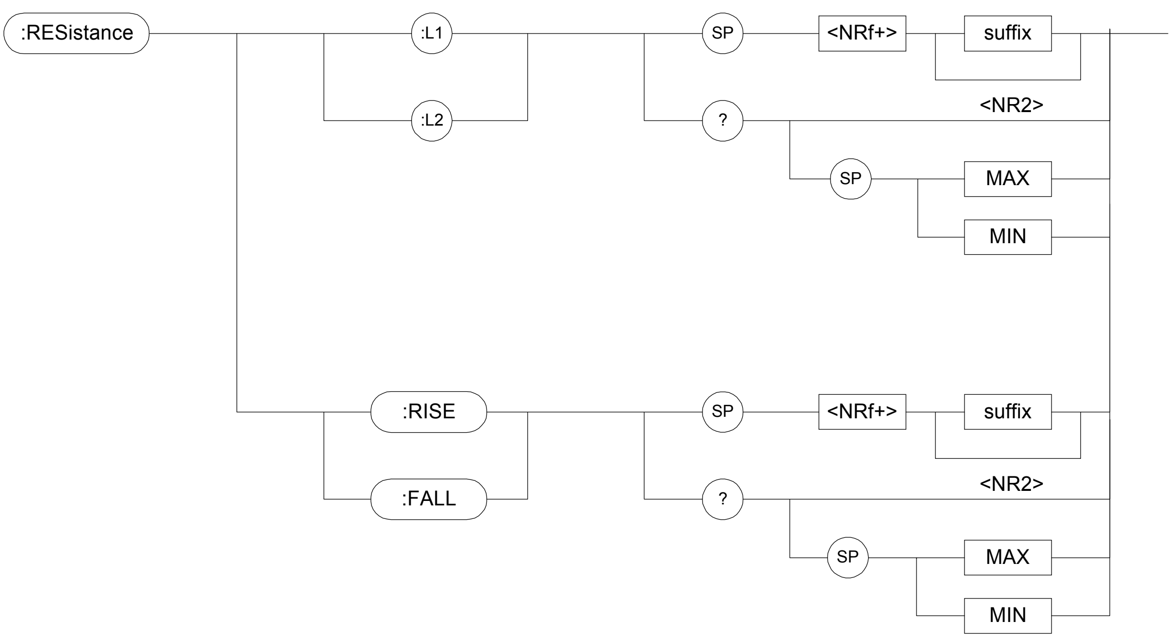
Description: Saves the setting of program.

Syntax: PROGram:SAVE

Parameters: NONE

Example: PROG:SAVE

5.10.10 RESISTANCE Subsystem



RESistance:L1/L2

Type: Channel-specific

Description: Sets static resistance level of constant resistance mode.

Syntax: RESistance:L1 <NRf+> [suffix]

RESistance:L2 <NRf+> [suffix]

Parameters: For valid value range, refer to respective specification.

Example:	RES:L1 20 OHM	Sets constant resistance = 20 ohm for Load L1.
	RES:L2 10 OHM	Sets constant resistance = 10 ohm for Load L2.
	RES:L1 MAX	Sets constant resistance = maximum L1 value for Load L1.
	RES:L2 MIN	Sets constant resistance = minimum L2 value for Load L2.
Query Syntax:	RESistance:L1?	
	RESistance:L2?	
	RESistance:L1? MAX	
	RESistance:L2? MIN	
Return Parameters:	<NR2> [Unit=OHM]	
Query Example:	RES:L1?	Returns the set resistance of the value of Load L1.
Return Example:	10	

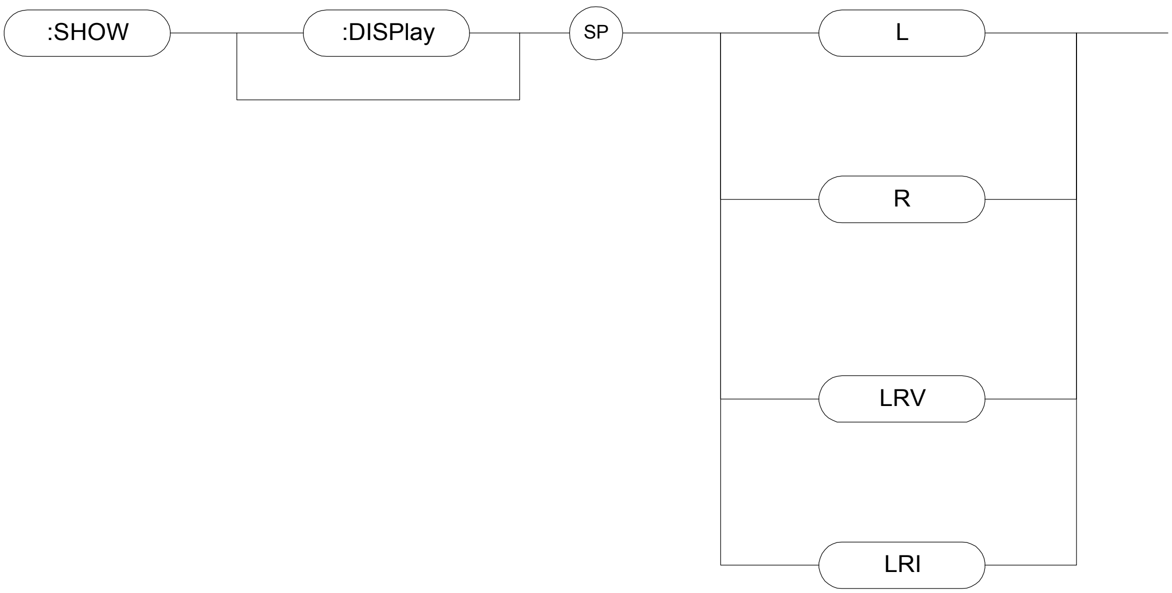
RESistance:RISE/FALL

Type:	Channel-specific	
Description:	Sets resistive slew rate of constant resistance.	
Syntax:	RESistance:RISE	<NRf+> [suffix]
	RESistance:FALL	<NRf+> [suffix]
Parameters:	For valid value range, refer to respective specification.	
Example:	RES:RISE 2.5	Sets CR rise slew rate as 2.5A/µS.
	RES:FALL 1A/µS	Sets CR fall slew rate as 1A/µS.
	RES:RISE MAX	Sets CR rise slew rate as the maximum programmable value.
	RES:FALL MIN	Sets CR fall slew rate as the minimum programmable value.
Query Syntax:	RESistance:RISE?	
	RESistance:FALL?	
	RESistance:RISE? MAX	
	RESistance:FALL? MIN	
Return Parameters:	<NR2> [Unit=OHM]	
Query Example:	RES:RISE?	Returns CR rise slew rate.
Return Example:	2.5	

5.10.11 RUN Subsystem

Type:	All Channel
Description:	Sets all electronic loads as “ON”.
Syntax:	RUN

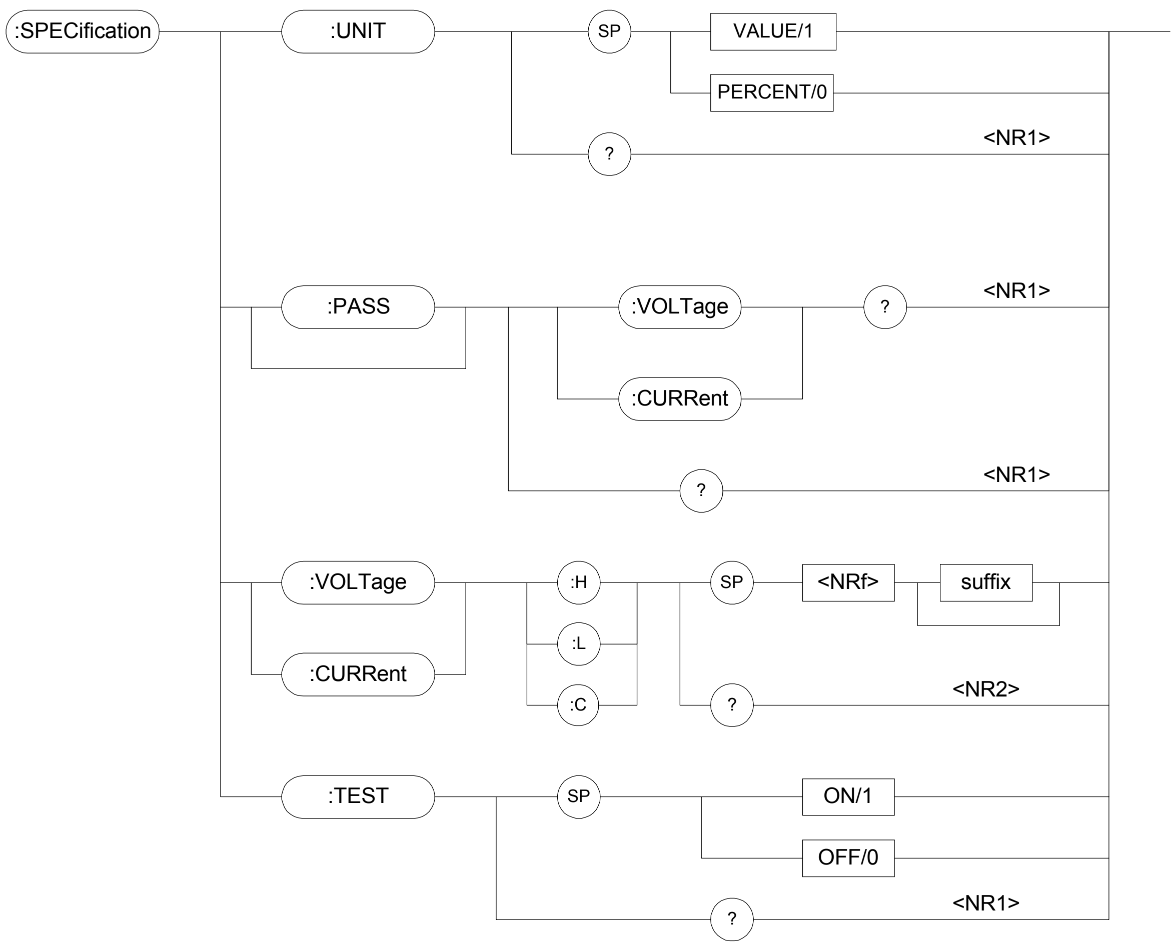
5.10.12 SHOW Subsystem



SHOW:DISPlay

Type:	Channel-specific (Double Channel Module Only)	
Description:	Sets the display mode of the electronic load.	
Syntax:	SHOW:DISPlay L SHOW:DISPlay R SHOW:DISPlay LRV SHOW:DISPlay LRI	
Parameters:	L, R, LRV, LRI.	
Example:	SHOW:DISP L	Displays the voltage and current values of channel L.
	SHOW:DISP R	Displays the voltage and current values of channel R.
	SHOW:DISP LRV	Displays the voltage value of channel L and channel R.
	SHOW:DISP LRI	Displays the current value of channel L and channel R.

5.10.13 SPECIFICATION Subsystem



SPECification:UNIT

Type: All Channel

Description: Sets the specific entry mode.

Syntax: SPECification:UNIT VALUE
SPECification:UNIT PERCENT

Parameters: VALUE/1, PERCENT/0

Example: SPEC:UNIT VALUE
SPEC: UNIT PERCENT

Query Syntax: SPECification:UNIT?

Query Example: SPEC:UNIT?

Return Parameters: <NR1>

Return Example: 0

SPECification:VOLTage?

Type:	Channel-specific	
Description:	Requests GO-NG result reference to voltage specification.	
Query Syntax:	SPECification:VOLTage?	
Query Example:	SPEC:VOLT?	Returns voltage GO-NG result to CC and CR modes.
Return Parameters:	<NR1>	
Return Example:	0 (NG), 1 (GO)	

SPECification:CURRent?

Type:	Channel-specific	
Description:	Requests GO-NG result reference to current specification.	
Query Syntax:	SPECification:CURRent?	
Query Example:	SPEC:CURR?	Returns current GO-NG result to CC mode.
Return Parameters:	<NR1>	
Return Example:	0 (NG), 1 (GO)	

SPECification?

Type:	All Channel	
Description:	Requests GO-NG result reference to all channel specification.	
Query Syntax:	SPECification?	
Query Example:	SPEC?	Returns all channel GO-NG result.
Return Parameters:	<NR1>	
Return Example:	0 (NG), 1 (GO)	

SPECification:VOLTage

Type:	Channel-specific
Description:	Sets the voltage specification.
Syntax:	SPECification:VOLTage:H SPECification:VOLTage:L SPECification:VOLTage:C
Parameters:	For valid value range, refer to respective specification.
Example:	SPEC:VOLT:H <NRf+> [suffix] SPEC:VOLT:L <NRf+> [suffix] SPEC:VOLT:C <NRf+> [suffix]

Query Syntax:	SPECification:VOLTage:H?
	SPECification:VOLTage:L?
	SPECification:VOLTage:C?
Query Example:	SPEC:VOLT:H?
Return Parameters:	<NR2> [Unit=Voltage]
Return Example:	4.75

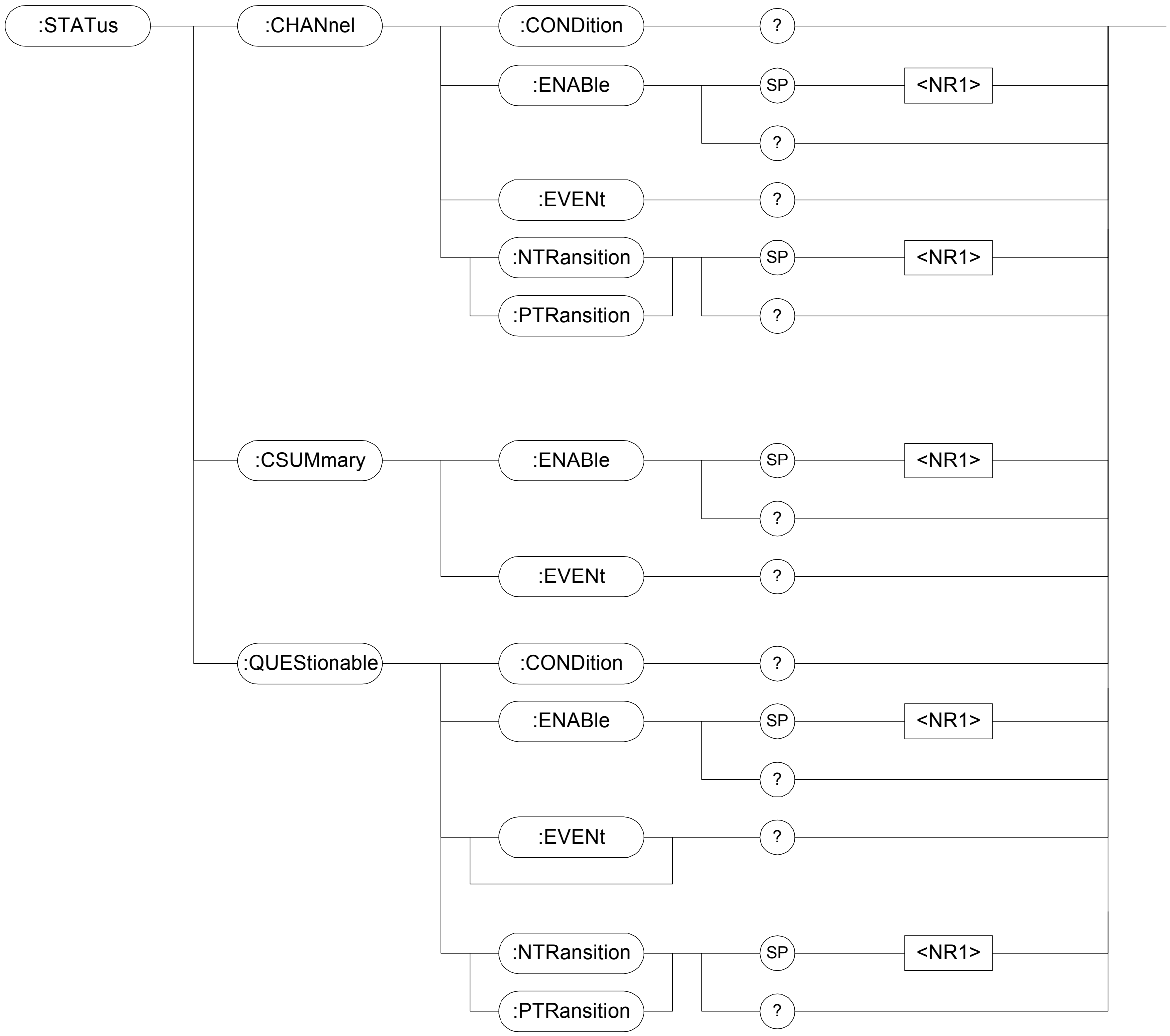
SPECification:CURRent

Type:	Channel-specific
Description:	Sets the current specification.
Syntax:	SPECification:CURRent:H
	SPECification:CURRent:L
	SPECification:CURRent:C
Parameters:	For valid value range, refer to respective specification.
Example:	SPEC:CURR:H <NRf+> [suffix]
	SPEC:CURR:L <NRf+> [suffix]
	SPEC:CURR:C <NRf+> [suffix]
Query Syntax:	SPECification:CURR:H?
	SPECification:CURR:L?
	SPECification:CURR:C?
Query Example:	SPEC:CURR:H?
Return Parameters:	<NR2> [Unit=Current]
Return Example:	4.75

SPECification:TEST

Type:	Channel-specific
Description:	Starts or closes the specification test.
Syntax:	SPECification:TEST ON
	SPECification:TEST OFF
Parameters:	ON/1, OFF/0
Example:	SPEC:TEST ON
	SPEC: TEST OFF
Query Syntax:	SPECification:TEST?
Query Example:	SPEC:TEST?
Return Parameters:	<NR1>
Return Example:	1

5.10.14 STATUS Subsystem



STATus:CHANnel:CONDition

Type: Channel-specific

Description: Returns real time channel status.

Query Syntax: STATus:CHANnel:CONDition?

Return Parameters: <NR1>

Bit Configuration of Channel Status Register

Bit Position	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Condition	0	0	0	0	0	0	0	0	0	0	0	OT	RV	OP	OV	OC
Bit Weight												16	8	4	2	1

Query Example: STAT:CHAN:COND? Returns status of the electronic load.

Return Example: 2048

STATus:CHANnel:ENABle

Type: Channel-specific

Description: Masks for selecting which bits in the Event register are allowed to be summed into the corresponding channel bit of the Channel Summary Event register.

Syntax: STATus:CHANnel:ENABle

Parameters: 0 ~ 65535

Example: STAT:CHAN:ENABl 24

Query Syntax: STATus:CHANnel:ENABle

Return Parameters: <NR1>

Query Example: STAT:CHAN:ENABL? Returns the contents of the Status Channel Enable register.

Return Example: 24

STATus:CHANnel:EVENt?

Type: Channel-specific

Description: Records all channel events that have occurred since last time the register was read, and resets the Channel Event register.

Query Syntax: STATus:CHANnel:EVENt?

Return Parameters: <NR1>

Query Example: STAT:CHAN:EVEN? Reads and resets Channel Event register.

Return Example: 24

STATus:CHANnel:PTRansition/NTRansition

Type:	Channel-specific	
Description:	Programmable filters that determine what type of transition (0 to 1 or 1 to 0) in the Condition register will set the corresponding bit of the Event register.	
Syntax:	STATus:CHANnel:PTRansition/NTRansition <NRf>	
Parameters:	0 ~ 65535	
Example:	STAT:CHAN:PTR 4	Sets OP (over power bit 2) as 0 to 1.
	STAT:CHAN:NTR 4	Sets OP (over power bit 2) as 1 to 0.
Query Syntax:	STATus:CHANnel:PTRansition?	
	STATus:CHANnel:NTRansition?	
Return Parameters:	<NR1>	
Query Example:	STAT:CHAN:PTR?	Inquires setting of Channel PTRansition.
Return Example:	4	

STATus:CSUMmary:ENABle

Type:	Channel-specific
Description:	Masks for selecting which bits in the Channel Event register are allowed to be summed into the CSUM (Channel Summary) bit of the Status Byte register.
Syntax:	STATus:CSUMmary:ENABle
Parameters:	

Bit Configuration of Channel Summary Register

Bit Position	7	6	5	4	3	2	1	0
Channel	8	7	6	5	4	3	2	1
Bit Weight	128	64	32	16	8	4	2	1

Example:	STAT:CSUM:ENAB 3	
Query Syntax:	STATus:CSUMmary:ENABle?	
Return Parameters:	<NR1>	
Query Example:	STAT:CSUM:ENAB?	Returns the setting of Channel Summary Enable register.
Return Example:	3	

STATus:CSUMmary:EVENt

Type: Channel-specific

Description: Indicates all channels on which an enable STAT:CHAN Event has occurred since last time the register was read.

Syntax: STATus:CSUMmary:EVENt

Parameters:

Bit Configuration of Channel Summary Register

Bit Position	7	6	5	4	3	2	1	0
Channel	8	7	6	5	4	3	2	1
Bit Weight	128	64	32	16	8	4	2	1

Example: STAT:CSUM:EVEN 3

Query Syntax: STATus:CSUMmary:EVENt?

Return Parameters: <NR1>

Query Example: STAT:CSUM:EVEN? Returns the value of the Channel Summary Event register.

Return Example: 3

STATus:QUEStionable:CONDition

Type: Channel-specific

Description: Real-time recording of Questionable data

Query Syntax: STATus:QUEStionable:CONDition?

Return Parameters: <NR1>

Query Example: STAT:QUES:COND? Returns the channel status.

Return Example: 6

STATus:QUEStionable:ENABle

Type: Channel-specific

Description: Masks for selecting which bits on the Event register are allowed to be summed into the QUES bit of the Status Byte register.

Syntax: STATus:QUEStionable:ENABle

Parameters :

Bit Configuration of Questionable Status Register

Bit Position	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Condition	0	0	0	0	0	0	0	0	0	0	0	TE	RV	PE	VE	CE
Bit Weight												16	8	4	2	1

Example:	STAT:QUES:ENAB 24	
Query Syntax:	STATus:QUEStionable:ENABle?	
Return Parameters:	<NR1>	
Query Example:	STAT:QUES:ENAB	Returns the setting of the Status Questionable Enable register.
Return Example:	24	

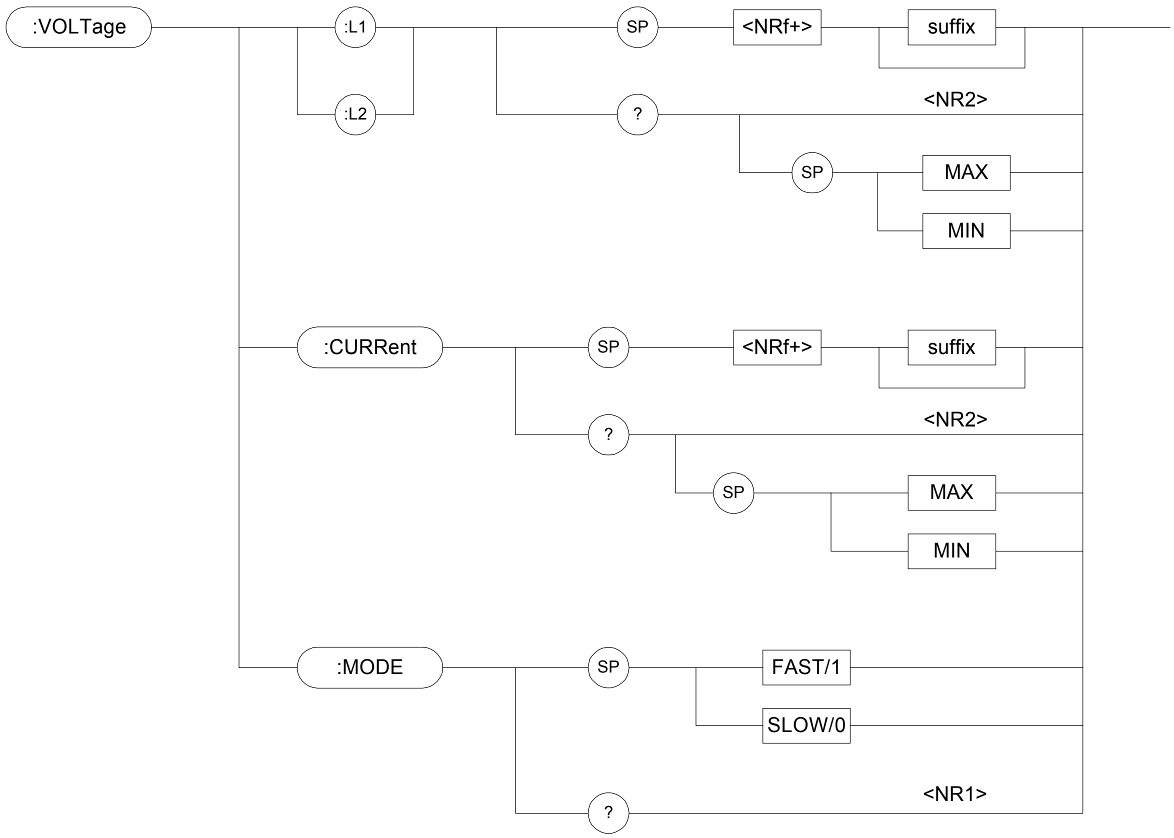
STATus:QUEStionable:EVENt?

Type:	Channel-specific	
Description:	Records all Questionable conditions that have occurred since last time the register was read.	
Query Syntax:	STATus:QUEStionable:EVENt?	
Return Parameters:	<NR1>	
Query Example:	STAT:QUES:EVEN?	Returns the contents of the Questionable Event register.
Return Example:	24	

STATus:QUEStionable:PTRansition/NTRansition

Type:	Channel-specific	
Description:	Programmable filters determine what type of transition (0 to 1 or 1 to 0) in the Condition register will set the corresponding bit of the Event register.	
Syntax:	STATus:QUEStionable:PTRansition/NTRansition <NRf>	
Parameters:	0 ~ 65535	
Example:	STAT:QUES:PTR 4	Sets OP (over power bit 2) as 0 to 1.
	STAT:QUES:NTR 4	Sets OP (over power bit 2) as 1 to 0.
Query Syntax:	STATus:QUEStionable:PTRansition?	
	STATus:QUEStionable:NTRansition?	
Return Parameters:	<NR1>	
Query Example:	STAT:QUES:PTR?	Returns the setting on the QUEStionable Ptransition/Ntransition.
Return Example:	4	

5.10.15 VOLTAGE Subsystem



VOLTage:L1/L2

Type:	Channel-specific	
Description:	Sets voltage of static load during constant voltage mode.	
Syntax:	VOLTage:L1	
	VOLTage:L2	
Parameters:	For valid value range, refer to respective specification.	
Example:	VOLT:L1 8V	Sets voltage of load L1 as 8V.
	VOLT:L2 24V	Sets voltage of load L2 as 24V.
	VOLT:L1 MAX	Sets voltage of load L1 as the maximum value.
	VOLT:L2 MIN	Sets voltage of load L2 as the minimum value.
Query Syntax:	VOLTage:L1?	
	VOLTage:L2?	
	VOLTage:L1? MAX	
	VOLT:L2? MIN	

Return Parameters:	<NR2> [Unit=Voltage]	
Query Example:	VOLT:L1?	Returns the set voltage value of load L1.
Return Example:	0	

VOLTage:CURRent

Type:	Channel-specific	
Description:	Sets the current limit of constant voltage mode.	
Syntax:	VOLTage:CURRent	
Parameters:	For valid value range, refer to respective specification.	
Example:	VOLT:CURR 3	Sets loading current limit as 3A during constant voltage mode.
	VOLT:CURR MAX	Sets loading current limit as the maximum value during constant voltage mode.
	VOLT:CURR MIN	Sets loading current limit as the minimum value during constant voltage mode.
Query Syntax:	VOLTage:CURRent?	
Return Parameters:	<NR2> [Unit=Amper]	
Query Example:	VOLT:CURR?	
Return Example:	3	

VOLTage:MODE

Type:	Channel-specific
Description:	Sets the response speed of CV mode.
Syntax:	VOLTage:MODE FAST
	VOLTage:MODE SLOW
Parameters:	FAST/1, SLOW/0
Example:	VOLT: MODE FAST
	VOLT:MODE SLOW
Query Syntax:	VOLTage:MODE?
Return Parameters:	<NR1>
Query Example:	VOLT:MODE?
Return Example:	0

5.11 Status Reporting

5.11.1 Introduction

This section discusses the status data structure of the MML series electronic load as shown in Figure 5-2. The standard registers, such as the Event Status register group, the Output Queue, the Status Byte and Service Request Enable registers perform standard GPIB functions and are defined in IEEE-488.2 Standard Digital Interface for Programmable Instrumentation. Other status register groups implement the specific status reporting requirements of the electronic load. The Channel Status and Channel Summary groups are used by multiple channel of electronic load to enable status information to be kept at its own Status register of each channel.

5.11.2 Register Information in Common

Condition Register
The condition register represents the present status of electronic load signals. Reading the condition register does not change the state of its bits. Only changes in electronic load conditions affect the contents of this register.

PTR/NTR Filter, Event Register
The Event register captures changes in conditions corresponding to condition bits in a condition register, or to a specific condition in the electronic load. An event becomes true when the associated condition makes one of the following electronic load-defined transitions:

Positive TRansition (0 to 1)

Negative TRansition (1 to 0)

Positive or Negative TRansition (0 to 1 or 1 to 0)

The PTR/NTR filters determine what type of condition transitions sets the bits in the Event register. Channel Status and Questionable Status allow transitions to be programmed. Other register groups, i.e., Channel Summary, Standard Event Status register group use an implied Rise (0 to 1) condition transition to set bits in the Event register. Reading an Event register clears the register (all bits are set to zero).

Enable Register
The Enable register can be programmed to enable which bit in the corresponding Event register is logically-ORed into the Channel Summary bit.

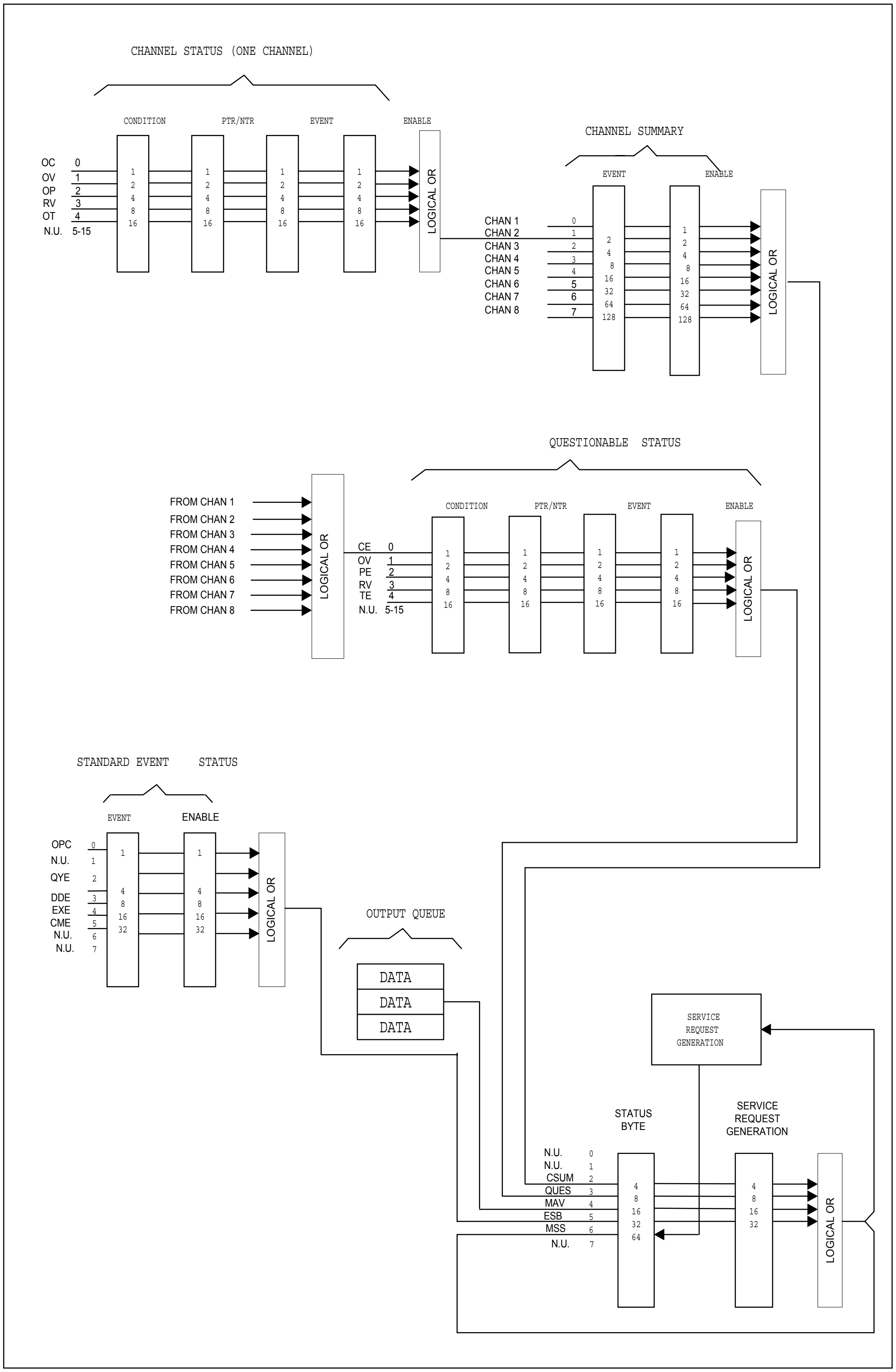


Figure 5-2 Status Registers of Electronic Load

Mnemonic	Bit	Value	Meaning
OC	0	1	*Overcurrent*. When an overcurrent condition has occurred on a channel, Bit 0 is set and remains set until the overcurrent condition is removed and LOAD:PROT:CLE is programmed.
OV	1	2	*Overvoltage*. When an overvoltage condition has occurred on a channel, Bit 1 is set and remains set until the overvoltage condition is removed and LOAD:PROT:CLE is programmed.
OP	2	4	*Overpower.* An overpower condition has occurred on a channel, Bit 2 is set and remains set until the overpower condition is removed and LOAD:PROT:CLE is programmed.
RV	3	8	*Reverse voltage on input.* When a channel has a reverse voltage applied to it, Bit 3 is set. It remains set until the reverse voltage is removed and LOAD:PROT:CLE is programmed.
OT	4	16	*Overtemperature*. When an overtemperature condition has occurred on a channel, Bit 4 is set and the channel is turned off. It remains set until the channel has cooled down well below the overtemperature trip point and LOAD:PROT:CLE is programmed.

Table 5-5 Bit Description of Channel Status

5.11.3 Channel Status

The Channel Status register offers you one or more channel status conditions, which indicate certain errors or faults have occurred on specific channel. Table 5-5 describes the channel status conditions that are applied to the electronic load.

When the bits of the Channel Status Condition register are set, the corresponding condition is true.

Program the PTR/NTR filter to select which way of a condition transition on a bit in the Channel Status Condition register will set the corresponding bit in the Event registers. Reading of the Channel Status Event register resets itself to zero.

The Channel Status Enable register can be programmed to specify which channel status event bit is logically-ORed to become the corresponding channel bit in the Channel Summary Event register.

5.11.4 Channel Summary

The Channel Summary registers summarize the channel status conditions of up to 8 channels.

When an enabled bit in the Channel Status Event register is set, it causes the corresponding channel bit in the Channel Summary Event register to be set.

Reading of the Event register will reset it to zero.

The Channel Summary Enable register can be programmed to specify which channel summary event bit from the existing channels is logically-ORed to become Bit 2 (CSUM bit) in the Status Byte register.

5.11.5 Questionable Status

The Questionable Status registers offer you one or more questionable status conditions, which indicate certain errors or faults have occurred on at least one channel. Table 5-6 lists the questionable status conditions that are applied to the electronic load. These conditions are the same as the channel status conditions. Refer to Table 5-5 for a complete description.

When the corresponding bit of the Questionable Status Condition register is set, the indicated condition is true.

Program the PTR/NTR filter to select which way of a condition transition on a bit in the Questionable Status Condition register will set the corresponding bit in the Event registers. Reading the Questionable Status Event register will reset it to zero.

The Questionable Status Enable register can be programmed to specify which questionable status event bit is logically-ORed to become Bit 3 (QUES bit) in the Status Byte register.

Mnemonic	Bit	Value	Meaning
CE/OC	0	1	Current Error (Overcurrent)
OV	1	2	Overvoltage
PE/OP	2	4	Power Error (Overpower)
RV	3	8	Reverse voltage on input
TE/OT	4	16	Temperature Error (Overtemperature)

Table 5-6 Bit Description of Questionable Status

5.11.6 Output Queue

The Output Queue stores output messages sequentially on a FIFO (First-In, First-Out) basis until they are read from the electronic load. When there are data in the queue, it sets it to 4 (MAV bit) in the Status Byte register.

5.11.7 Standard Event Status

All programming errors that have occurred will set one or more of the error bits in the Standard Event Status register. Table 5-7 describes the standard events that apply to the electronic load. Reading of the Standard Event Status register will reset it to zero.

The Standard Event Enable register can be programmed to specify which standard event bit is logically-ORed to become Bit 5 (ESB bit) in the Status Byte register.

Mnemonic	Bit	Value	Meaning
OPC	0	1	*Operation Complete.* This event bit is a response to the *OPC command. It indicates that the device has completed all selected pending operations.
QYE	2	4	*Query Error*. The output queue was read when no data were present or the data in the queue were lost.
DDE	3	8	*Device Dependent Error.* Memory was lost, or self-test failed.
EXE	4	16	*Execution Error*. A command parameter was outside the legal range or inconsistent with the electronic load's operation, or the command could not be executed due to some operating condition.
CME	5	32	*Command Error.* A syntax or semantic error has occurred, or the electronic load has received a <GET> within a program message.

Table 5-7 Bit Description of Standard Event Status

5.11.8 Status Byte Register

The Status Byte register summarizes all of the status events from all status registers. Table 5-8 describes the status events that are applied to the electronic load.

The Status Byte register can be read with a serial poll or *STB? query. The RQS bit is the only bit that is automatically cleared after a serial poll.

When the Status Byte register is read with a *STB? query, bit 6 of the Status Byte register will contain the MSS bit. The MSS bit indicates that the load has at least one reason for requesting service. *STB? does not affect the status byte.

The Status Byte register is cleared by *CLS command.

Mnemonic	Bit	Value	Meaning
CSUM	2	4	*Channel Summary*. Indicates if an enabled channel event has occurred. It is affected by Channel Condition, Channel Event and Channel Summary Event registers.
QUES	3	8	*Questionable*. Indicates if an enabled questionable event has occurred.
MAV	4	16	*Message Available.* Indicates if the Output Queue contains data.
ESB	5	32	*Event Status Bit*. Indicates if an enabled standard event has occurred.
RQS/MSS	6	64	*Request Service/Master Summary Status.* During a serial poll, RQS is returned and cleared. For an *STB? query, MSS is returned without being cleared.

Table 5-8 Bit Description of Status Byte

5.11.9 Service Request Enable Register

The Service Request Enable register can be programmed to specify which bit in the Status Byte register will generate service requests.

6 PROGRAMMING EXAMPLE

This section provides a basic example of controlling the electronic load via GPIB. The GPIB used here is made by *National Instruments*.

```
#include "dec1.h"

#include <stdio.h>
#include <stdlib.h>
#include <sring.h>
#include <iostream.h>
#include <time.h>

static int MTA,
               MLA;

static int bd;

const char LA = 0x20,
 TA = 0x40;

static void setNi( int pad, char *cardName )
{
   MTA = TA + pad;
   MLA = LA + pad;
   if ( (bd = ibfind ( cardName ) ) < 0 )  {
 puts ( "GPIB Card Found Error" );
 exit ( 1 );
   }
   if ( ibpad ( bd, pad ) & ERR )  {
      puts ( "GPIB Card Address Assignment Error" );
      exit ( 3 );
   }
   ibtmo ( bd, 10 );
ibsic ( bd );
ibsre ( bd, 1 );
  }

  static void Niwrite( int pad, char *cmdStr )
  {
     char cmd[4];

    cmd[0]  = UNL;
cmd[1]  = UNT;
cmd[2]  = MTA;
cmd[3]  = LA + pad;
//
ibcmd( bd, cmd, 4 );
ibwrt ( bd, cmdStr, _fstrlen( cmdStr ) );
ibcmd( bd, cmd, 2 );
```

```
}

static char rxBuf[ 64 ]

static void Niread( int pad, char *queryStr )
{
   char cmd[ 4 ];

Niwrite( pad, queryStr );
cmd[ 0 ] = UNL;
cmd[ 1 ] = UNT;
cmd[ 2 ] = TA + pad;
cmd[ 3 ] = MLA;
         //
       ibcmd( bd, cmd, 4 );
ibrd( bd, rxBuf, sizeof( rxBuf ) - 1 );
rxBuf[ ibcnt ] = ‘ \0 ’;
ibcmd( bd, cmd, 2);
 }

void main( )
{
  setNi( 0, “GPIB” );// Sets the status of PC’s GPIB CARD.    //
Niread( 8, “*IDN?” );// Reads back indentity code of MML-4.
  cout << rxBuf << “ \n\r ”;      // Displays on the screen of PC.
//
Niwrite( 8, “CHAN 1” );// Sets CHANNEL as 1.
//
Niread( 8,  “CHAN:ID?” ); // Reads back identity code of channel
1.cout << rxBuf << “ \n\r ”;// Displays on the screen of PC.
        //
Niwrite( 8, “MODE CCL” );     // Sets CHANNEL 1 MODE as CCL.Niwrite (
8, “CURR:STATIV:L1 1” ):   // Sets L1 current of CCL as 1A.
//
Niread( 8,  “LOAD ON” );  // Starts sinking current.
//
Niread( 8, “MEAS:VOLT?” );  // Measures the readings of voltage.
cout << rxBuf << “ \n\r ”;  // Displays on the screen of PC.
//
Niread( 8, “MEAS:CURR?” );  // Measures the readings of current.
cout << rxBuf << “ \n\r ”;  // Displays on the screen of PC.
Niread( 8, “LOAD OFF” );  // Stops sinking current.
//
        ibsic ( bd );
ibonl( bd, 0 );
ibsre ( bd, 0 );
 }
```

For the above example, please refer to Chapter 3, and add corresponding commands according to settings and controls.

7 CALIBRATION PROCEDURES

7.1 Introduction

This section covers the calibration procedures of the MML series load modules. The load modules should be calibrated annually, or whenever some repairs are made. To calibrate a load module, you must disconnect the load module from the mainframe, and open the module's cover for measurement and/or adjustment. Refer to subsection 7.9 for removing load modules. Use a ribbon cable (P/N: 881-803-31) to connect the load module with the mainframe for calibration. For model MML-80-120-601 and MML-500-20-601 two ribbon cables are needed for connection. When removing a load module from the mainframe, you must put a fan on the back of the module to dissipate heat.

Refer to figure 7-1, 7-2, 7-3 for CC, CR, CV calibration equipment setup.

For manual calibration, press LOAD to disable the load module input when you change mode or range, and press this key again to enable. After calibration, turn off the power, reassemble the load module, and replace the module into the mainframe.

Press A/B and STATIC/DYNA simultaneously and hold it for approximately 2 seconds to enter into the calibration mode, you must follow the calibration sequence. In calibration mode, press A/B or R/L to go to the previous calibration procedure, and press STATIC/DYNA to go to the next procedure, and press LOAD to save data and go to the next procedure. After calibration, you must turn off the power, and turn it on again to initialize the calibration data.

7.2 Test and Calibration Setup Configuration

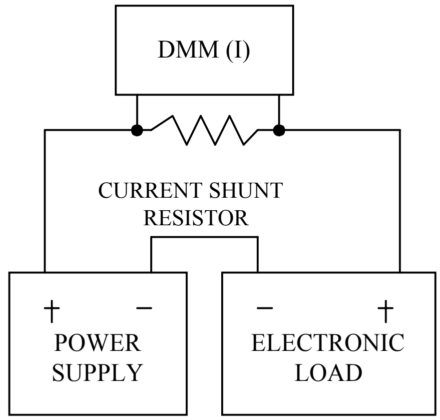


Figure 7-1 Test Setup for CC Mode

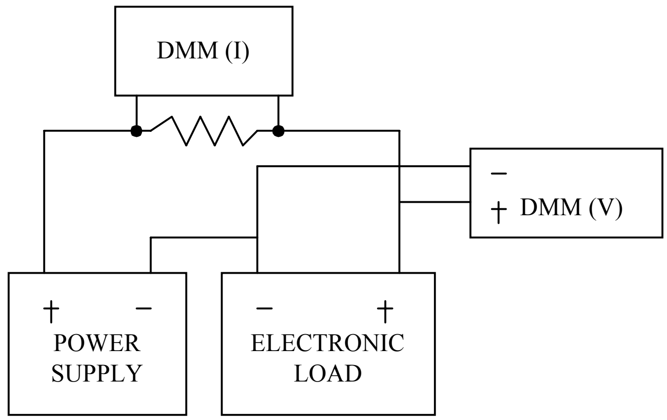


Figure 7-2 Test Setup for CR Mode

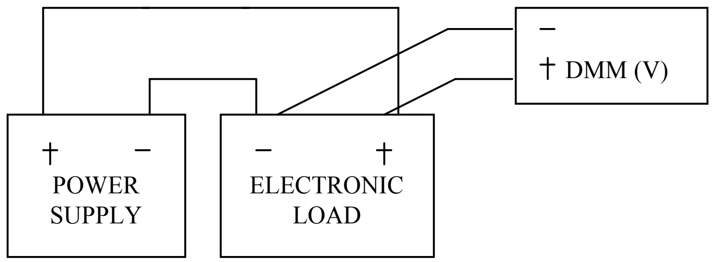


Figure 7-3 Test Setup for CV Mode

7.3 Required Test Equipment

The required test equipment is shown below.

Type	Required Characteristics	Recommended Model
DMM	5 1/2 digits or more	HP34401A, HP3458A
Current Shunt	0.05% accuracy 10 ohms@20mA 0.1 ohms@2A 0.01 ohms@20A 0.001 ohms@250A/100A (250A for models of 63106, 63112)	PRODIGIT 7550 VALHALLA 2575A
DC Sources	***For:*** MML-80-20-102 ***For:*** MML-80-60-301 ***For:*** MML-80-120-601 ***For:*** MML-500-10-301 ***For:*** MML-500-20-601	***Use:*** DLM80-7.5 and DLM8-75 ***Use:*** DLM80-7.5 and DLM8-75 ***Use:*** DLM80-7.5 and DCS8-125 ***Use:*** DCS600-1.7E and DLM8-75 ***Use:*** DCS600-1.7E and DLM8-75
Oscilloscope	100MHz	Tektronics TDS340
Extender Cable	32-pin ribbon cable	Chroma part No. 806 31000
DC Power Supply	12V, 3A	GW3030
FAN	100 CFM	FLOWMAX 4715KL-04W-B30(DC:12V)

NOTE

The TPA7, TPB7 ... And VRA5, VRB5 ... are referred to in many of the troubleshooting/check/adjustment procedures. TPA represents the test point on side A while TPB that on side B. TPB is only used by the dual channel/ module of the left channel. VRA represents the variable resistor on side A while VRB that on side B. VRB is only used by the dual channel/module of the left channel. Side A is isolated from side B.

7.4 Calibration Procedures of MML-80-20-102

Reference voltage adjustment:

1. Channel L adjustment

Connect DMM+ to TPB4 on board A , DMM– to TPB3 on board A.

Adjust VRB4 on board A until DMM (DC) = –10.2400 ± 0.0005V.

Connect DMM+ to TPB6 on board L, DMM– to TPB3 on board A.

Adjust VRB10 on board L until DMM (DC) = 2.5600 ± 0.0002V.

2. Channel R adjustment

Connect DMM+ to TPA4 on board A, DMM– to TPA3 on board A.

Adjust VRA4 on board A until DMM (DC) = –10.2400 ± 0.0005V.

Connect DMM+ to TPA6 on board L, DMM– to TPA3 on board A.

Adjust VRA10 on board L until DMM (DC) = 2.5600 ± 0.0002V.

Measurement offset calibration:

Short channel L input terminals. Press R-/L and STATIC/DYNA simultaneously over one second, and the module will go to calibration mode.

Adjust VRB11 on board L till the module's display is as follows:

LoFFS	<<– offset calibration of low range voltage in channel L
00XX	<<– xx:25 to 40(hex)

Press LOAD , wait two seconds, and check the module's display:

HoFFS	<<– offset calibration of high range voltage in channel L
00XX	<<– xx:25 to 40(hex)

Press LOAD, wait two seconds, and check the module's display:

LoFFS	<<– offset calibration of low range current in channel L
00XX	<<– xx:25 to 40(hex)

Press LOAD , wait two seconds, and check the module's display:

HoFFS	<<– offset calibration of high range current in channel L
00XX	<<– xx:25 to 40(hex)

Short Channel R input terminals.

Press LOAD and adjust VRA11 on board L till the module's display is as follows:

LoFFS	<<– offset calibration of low range voltage in channel R
00XX	<<– xx:25 to 40(hex)

Press LOAD , wait two seconds, and check the module's display:

HoFFS	<<– offset calibration of high range voltage in channel R
00XX	<<– xx:25 to 40(hex)

Press LOAD , wait two seconds, and check the module's display:

LoFFS	<<– offset calibration of low range current in channel R
00XX	<<– xx:25 to 40(hex)

Press LOAD , wait two seconds, and check the module's display:

HoFFS	<<– offset calibration of high range current in channel R
00XX	<<– xx:25 to 40(hex)

Press LOAD to let the module go to normal display mode.

Remove input terminal's short circuit.

Voltage measurement adjustment (channel L):

Set channel L of the load module to CRH mode.

Apply DC source to the input terminals of channel L, and set the DC source to 80V and current limit 1A. Connect DMM to input terminals of channel L. Adjust VRB9 on board L until the display of voltage in channel L = DMM (V) reading ± 0.01V.

Current offset adjustment (channel L):

Set the DC source to 5V/200mA and current shunt range to 20mA.

Set channel L to CCL mode and program the current to 2mA.

Adjust VRB2 on board L until shunt current = 1.95 to 2.05mA.

Set channel L to CCH mode and program the current to 20mA.

Adjust VRB6 on board L until shunt current = 19.8 to 20.2mA.

Current setting/measurement adjustment (channel L):

Set the DC source to 5V/2.1A and current shunt range to 2A.
Set channel L to CCL mode and program the current to 2A.
Adjust VRB1 on board L until shunt current = 1.999 to 2.001A.
Adjust VRB3 on board L until display current = 1.999 to 2.001A.

Set the DC source to 5V/21A and current shunt range to 20A.
Set channel L to CCH mode and program the current to 20A.
Adjust VRB5 on board L until shunt current = 19.99 to 20.01A.
Adjust VRB7 on board L until display current = 19.99 to 20.01A.

CR mode adjustment (channel L):

Set the DC source to 15V and current limit to 10A.
Set channel L to CRL mode and program resistance to 3 ohms.
Adjust VRB1 on board A until DMM (V) reading/3 ohms = shunt current ± 2mA.

CV mode adjustment (channel L):

Select CV mode of channel L and program CV voltage to 76V.
Set current limit of CV mode to 1A in configuration.
Set the DC source to 80V/0.1A.
Adjust VRB2 on board A until DMM (V) reading = 75.997 to 76.003V.

Voltage measurement adjustment (channel R):

Set channel R of the load module to CRH mode.
Apply DC source to the input terminals of channel R and set the DC source to 80V/0.1A.
Adjust VRA9 on board L until the display of voltage in channel R = DMM (V) reading ± 0.01V.

Current offset adjustment (channel R):

Set the DC source to 5V/200mA and current shunt range to 20mA.
Set channel R to CCL mode and program the current to 2mA.
Adjust VRA2 on board L until shunt current = 1.95 to 2.05mA.

Set channel R to CCH mode and program the current to 20mA.
Adjust VRA6 on board L until shunt current = 19.8 to 20.2mA.

Current setting/measurement adjustment (channel R):

Set the DC source to 5V/2.1A and current shunt range to 2A.

Set channel R to CCL mode and program the current to 2A.

Adjust VRA1 on board L until shunt current = 1.999 to 2.001A.

Adjust VRA3 on board L until display current = 1.999 to 2.001A.

Set the DC source to 5V/21A and current shunt range to 20A.

Set channel R to CCH mode and program the current to 20A.

Adjust VRA5 on board L until shunt current = 19.99 to 20.01A.

Adjust VRA7 on board L until display current = 19.99 to 20.01A.

CR mode adjustment (channel R):

Set the DC source to 15V/10A.

Set channel L to CRL mode and program resistance to 3 ohms.

Adjust VRA1 on board A until DMM (V) reading/3 ohms = shunt current ± 2mA.

CV mode adjustment (channel R):

Set channel L to CV mode and program CV voltage to 76V.

Set current limit of CV mode to 1A in configuration.

Set the DC source to 80V/0.1A.

Adjust VRA2 on board A until DMM (V) reading = 75.997 to 76.003V.

7.5 Calibration Procedures of MML-80-60-301

Reference voltage adjustment:

Connect DMM+ to TPA4 on board A , DMM– to TPA3 on board A.

Adjust VRA4 on board A until DMM (DC) = –10.2400 ± 0.0005V.

Connect DMM+ to TPA6 on board L, DMM– to TPA3 on board A.

Adjust VRA10 on board L until DMM (DC) = 2.5600 ± 0.0002V.

Measurement offset calibration:

Short the module's input terminals of +, –.

Press A/B and STATIC/DYNA simultaneously over one second to let the module go to calibration mode.

Adjust VRA11 on board L until the module's display is as follows:

Display	
LoFFS	<<– offset calibration of low range voltage
00XX	<<– xx:25 to 40(hex)

Press LOAD, wait two seconds, and check the module's display:

Display	
HoFFS	<<– offset calibration of high range voltage
00XX	<<– xx:25 to 40(hex)

Press LOAD , wait two seconds, and check the module's display:

Display	
LoFFS	<<– offset calibration of low range current
00XX	<<– xx:25 to 40(hex)

Press LOAD , wait two seconds, and check the module's display:

Display	
HoFFS	<<– offset calibration of high range current
00XX	<<– xx:25 to 40(hex)

Remove input terminals' short circuit. Press LOAD to return to normal display mode.

Voltage measurement adjustment:

Set the load module to CRH mode.

Set the DC source to 80V/0.1A. Connect DMM to the module's input terminals.

Adjust VRA9 on board L until the display voltage = DMM (V) reading ± 0.01V.

Current offset adjustment:

Set the DC source to 5V/200mA and current shunt range to 200mA.

Set the load module to CCL mode and program the current to 6mA.

Adjust VRA2 on board L until shunt current = 5.9 to 6.1mA.

Set the load module to CCH mode and program the current to 60mA.

Adjust VRA6 on board L until shunt current = 59.5 to 60.5mA.

Current setting/measurement adjustment:

Set the DC source to 5V/7A and current shunt range to 20A.

Set the load module to CCL mode and program the current to 6A.

Adjust VRA1 on board L until shunt current = 5.997 to 6.003A.
Adjust VRA3 on board L until display current = 5.997 to 6.003A.

Set the DC source to 5V/61A and current shunt range to 100/250A.
Set the load module to CCH mode and program the current to 60A.
Adjust VRA5 on board L until shunt current = 59.97 to 60.03A.
Adjust VRA7 on board L until display current = 59.97 to 60.03A.

CR mode adjustment:
Set the DC source to 15V/20A and current shunt range to 20A.
Set the load module to CRL mode and program resistance to 1 ohm.
Adjust VRA1 on board A until DMM (V) reading/1 ohm = shunt current ± 3mA.

CV mode adjustment:
Set channel L to CV mode and program CV voltage to 76V.
Set current limit of CV mode to 1A in configuration.
Set the DC source to 80V/0.1A.
Adjust VRA2 on board A until DMM (V) reading = 75.997 to 76.003V.

7.6 Calibration Procedures of MML-500-10-301

Reference voltage adjustment:
Connect DMM+ to TPA4 on board A , DMM– to TPA3 on board A.
Adjust VRA4 on board A until DMM (DC) = –10.2400 ± 0.0005V.

Reference voltage check:
Connect DMM+ to TPA6 on board L , DMM– to TPA3 on board A.
Check DMM (DC) = 2.48 to 2.60V.

Software calibration procedures:
1. Measurement offset calibration
Short the module's input terminals of +, –.
Press A/B and STATIC/DYNA simultaneously over two seconds to let the module go to calibration mode.
The module displays:

Display	
LoFFS	<<– offset calibration of low range voltage
XXXX	xxxx: offset data of low range voltage measurement

Press LOAD , wait two seconds, and check the module's display:

HoFFS XXXX	<<– offset calibration of high range voltage xxxx: offset data of high range voltage measurement

Press LOAD , wait two seconds, and check the module's display:

LoFFS XXXX	<<– offset calibration of low range current xxxx: offset data of low range current measurement

Press LOAD , wait two seconds, and check the module's display:

HoFFS XXXX	<<– offset calibration of high range current xxxx: offset data of high range current measurement

Remove input terminals' short circuit.

2. Voltage measurement full-scale calibration

Press LOAD and the module displays:

```
2.FS
uL
```

Set the DC source to 125V/0.1A, and apply to the load module's input terminals.

Press LOAD and the module displays:

```
AAAAA
BBBBB
```

AAAAA represents the load module's voltage measurement before calibration.

BBBBB represents the load module's voltage measurement after calibration.

Adjust the knob of the module until DMM (V) reading = BBBBB ± 1 count.

Press LOAD and the module displays:

```
SAvE
```

Save the low range full-scale data.

Press LOAD and the module displays:

```
3.FS
uH
```

Set the DC source to 500V/0.1A.

Press LOAD and the module displays:

```
CCCCC
DDDDD
```

CCCCC represents the load module's voltage measurement before calibration.

DDDDD represents the load module's voltage measurement after calibration.

Adjust the knob of the module until DMM (V) reading = DDDDD ± 1 count.

Press LOAD and the module displays:

```
SAvE
```

Save the high range full-scale data.

3. Current measurement calibration

Press LOAD and the module displays:

```
4.FS
AL
```

Set the DC source to 5V/2.1A and current shunt range to 2A.

Press LOAD and the module displays:

```
EEEEE
FFFFF
```

EEEEE represents the load module's current measurement before calibration.

FFFFF represents the load module's current measurement after calibration.

Adjust the knob of the module until shunt current = FFFFF ± 1 count.

Press LOAD and the module displays:

SAvE

Save CCL measurement data.

Press LOAD and the module displays:

5.FS
AH

Set the DC source to 5V/21A and current shunt range to 20A.

Press LOAD and the module displays:

GGGGG
HHHHH

GGGGG represents the load module's current measurement before calibration.
HHHHH represents the load module's current measurement after calibration.
Adjust the knob of the module until shunt current = HHHHH ± 1 count.
Press LOAD and the module displays:

SAvE

Save CCH measurement data.

4. Current setting offset calibration

Set the DC source to 5V/20mA and current shunt range to 20mA.

Press LOAD and the module displays:

6.oFF
CCL

Press LOAD and the module displays:

KKKKK

Adjust the knob of the module until shunt current = 0 to 0.5mA.
Press LOAD and the module displays:

SAvE

Save CCL offset data.

Press LOAD and the module displays:

7.oFF
CCH

Press LOAD and the module displays:

LLLLL

Adjust the knob of the module until shunt current = 0 to 5mA.
Press LOAD and the module displays:

SAvE

Save CCH offset data.

5. Current setting calibration

Set the DC source to 5V/5A and current shunt range to 2A.
Press LOAD and the module displays:

8.FS
CCL

Press LOAD and the module displays:

0.9000
PPPPP

0.9000 represents the load module's current setting before calibration.

PPPPP represents the load module's current setting after calibration.

Adjust the knob of the module until shunt current = PPPPP ± 1 count.

Press LOAD and the module displays:

```
SAvE
```

Save CCL setting data.

Set the DC source to 5V/10A and current shunt range to 20A.

Press LOAD and the module displays:

```
9.FS
CCH
```

Press LOAD and the module displays:

```
9.0000
RRRRR
```

9.0000 represents the load module's current setting before calibration.

RRRRR represents the load module's current setting after calibration.

Adjust the knob of the module until shunt current = RRRRR ± 1 count.

Press LOAD and the module displays:

```
SAvE
```

Save CCH setting data.

6. CR mode calibration

Set the DC source to 20V/6A and current shunt range to 20A.

Press LOAD and the module displays:

```
10.FS
CrL
```

Press LOAD and the module displays:

```
5.0000
SSSSS
```

5.0000 represents the load module's resistance setting before calibration.
SSSSS represents the load module's resistance setting after calibration.
Adjust the knob of the module until DMM (V) reading/shunt current = SSSSS (ohms) ± 1 count.

Press LOAD and the module displays:

```
SAvE
```

Save CRL setting data.

Press LOAD and the module displays:

```
11.FS
CrH
```

Set the DC source to 50V/1A and current shunt range to 2A.

Press LOAD and the module displays:

```
20.000
TTTTT
```

20.000 represents the load module's resistance setting before calibration.
TTTTT represents the load module's resistance setting after calibration.

Note: Because of the module's display limitation, the resistance setting is 200 ohms, not 20 ohms.
Adjust the knob of the module until DMM (V) reading/shunt current = TTTTT (ohms) ± 1 count.

Press LOAD and the module displays:

```
SAvE
```

Save CRH setting data.

7. CV mode calibration

Set the DC source to 500V and current limit to 0.1A.

Press LOAD and the module displays:

```
12.FS
Cu
```

Press LOAD and the module displays:

```
475.00
UUUUU
```

475.00 represents the load module's CV voltage setting before calibration.
UUUUU represents the load module's CV voltage setting after calibration.
Adjust the knob of the module until DMM (V) reading = UUUUU ± 1 count.
Press LOAD and the module displays:

```
SAvE
```

Save CV setting data.
Recycle the power switch after calibration.

7.7 Calibration Procedures of MML-80-120-601

Reference voltage adjustment:

Connect DMM+ to TPA4 on board A , DMM– to TPA3 on board A.
Adjust VRA4 on board A until DMM (DC) = –10.2400 ± 0.0005V.

Reference voltage check:

Connect DMM+ to TPA6 on board L , DMM– to TPA3 on board A.
Check DMM (DC) = 2.48 to 2.60V.

Software calibration procedures:

1. **Measurement offset calibration**

Short the module's input terminals of +, –.
Press A/B and STATIC/DYNA simultaneously over one second to let the module go to calibration mode.

The module displays:

```
LoFFS
XXXX
```

<<– offset calibration of low range voltage
xxxx: offset data of low range voltage measurement

Press LOAD , wait two seconds, and check the module's display:

HoFFS XXXX	<<– offset calibration of high range voltage xxxx: offset data of high range voltage measurement

Press LOAD , wait two seconds, and check the module's display:

LoFFS XXXX	<<– offset calibration of low range current xxxx: offset data of low range current measurement

Press LOAD , wait two seconds, and check the module's display:

HoFFS XXXX	<<– offset calibration of high range current xxxx: offset data of high range current measurement

Remove input terminals' short circuit.

2. Voltage measurement full-scale calibration

Press LOAD and the module displays:

2.FS
uL

Set the DC source to 16V/0.1A, and apply DC source to the load module's input terminals.

Press LOAD and the module displays:

AAAAA
BBBBB

AAAAA represents the load module's voltage measurement before calibration.

BBBBB represents the load module's voltage measurement after calibration.

Adjust the knob of the module until DMM (V) reading = BBBBB ± 1 count.

Press LOAD and the module displays:

SAvE

Save the low range full-scale data.

Press LOAD and the module displays:

3.FS uH

Set the DC source to 80V/0.1A.

Press LOAD and the module displays:

CCCCC DDDDD

CCCCC represents the load module's voltage measurement before calibration.

DDDDD represents the load module's voltage measurement after calibration.

Adjust the knob of the module until DMM (V) reading = DDDDD ± 1 count.

Press LOAD and the module displays:

SAvE

Save the high range full-scale data.

3. Current measurement calibration

Press LOAD and the module displays:

4.FS AL

Set the DC source to 5V/15A and current shunt range to 20A.

Press LOAD and the module displays:

EEEEE FFFFF

EEEEE represents the load module's current measurement before calibration.

FFFFF represents the load module's current measurement after calibration.

Adjust the knob of the module until shunt current = FFFFF ± 1 count.

Press LOAD and the module displays:

SAvE

Save CCL measurement data.

Press LOAD and the module displays:

5.FS AH

Set the DC source to 5V/125A and current shunt range to 250A.

Press LOAD and the module displays:

GGGGG HHHHH

GGGGG represents the load module's current measurement before calibration.
HHHHH represents the load module's current measurement after calibration.
Adjust the knob of the module until shunt current = HHHHH ± 1 count.
Press LOAD and the module displays:

SAvE

Save CCH measurement data.

4. Current setting offset calibration

Set the DC source to 5V/20mA and current shunt range to 20mA.
Press LOAD and the module displays:

6.oFF CCL

Press LOAD and the module displays:

KKKKK

Adjust the knob of the module until shunt current = 0 to 3mA.

Press LOAD and the module displays:

```
SAvE
```

Save CCL offset data.

Press LOAD and the module displays:

```
7.oFF
CCH
```

Press LOAD and the module displays:

```
LLLLL
```

Adjust the knob of the module until shunt current = 0 to 30mA.

Press LOAD and the module displays:

```
SAvE
```

Save CCH offset data.

5. Current setting calibration

Set the DC source to 5V/15A and current shunt range to 20A.

Press LOAD and the module displays:

```
8.FS
CCL
```

Press LOAD and the module displays:

```
10.800
PPPPP
```

10.800 represent the load module's current setting before calibration.

PPPPP represents the load module's current setting after calibration.

Adjust the knob of the module until shunt current = PPPPP ± 1 count.

Press LOAD and the module displays:

SAvE

Save CCL setting data.

Set the DC source to 5V/125A and current shunt range to 250A.

Press LOAD and the module displays:

9.FS
CCH

Press LOAD and the module displays:

108.00
RRRRR

108.00 represents the load module's current setting before calibration.

RRRRR represents the load module's current setting after calibration

Adjust the knob of the module until shunt current = RRRRR ± 1 count.

Press LOAD and the module displays:

SAvE

Save CCH setting data.

6. CR mode calibration

Set the DC source to 1.5V/60A and current shunt range to 100A.

Press LOAD and the module displays:

10.FS
CrL

Press LOAD and the module displays:

0.0500
SSSSS

0.0500 represents the load module's resistance setting before calibration.

SSSSS represents the load module's resistance setting after calibration.
Adjust the knob of the module until DMM (V) reading/shunt current = SSSSS (ohms) ± 1 count.

Press LOAD and the module displays:

```
SAvE
```

Save CRL setting data.

Press LOAD and the module displays:

```
11.FS
CrH
```

Set the DC source to 5V/5A.

Press LOAD and the module displays:

```
2.5000
TTTTT
```

2.5000 represents the load module's resistance setting before calibration.
TTTTT represents the load module's resistance setting after calibration.
Adjust the knob of the module until DMM (V) reading/shunt current = TTTTT (ohms) ± 1 count.

Press LOAD and the module displays:

```
SAvE
```

Save CRH setting data.

7. CV mode calibration

Set the DC source to 80V/0.1A.
Press LOAD and the module displays:

```
12.FS
Cu
```

Press LOAD and the module displays:

76.000
UUUUU

76.000 represents the load module's CV voltage setting before calibration.
UUUUU represents the load module's CV voltage setting after calibration.
Adjust the knob of the module until DMM (V) reading = UUUUU ± 1 count.
Press LOAD and the module displays:

SAvE

Save CV setting data.
Recycle the power switch after calibration.

7.8 Calibration Procedures of MML-500-20-601

Reference voltage adjustment:
Connect DMM+ to TPA4 on board A, DMM– to TPA3 on board A.
Adjust VRA4 on board A until DMM (V) = –10.2400 ± 0.0005V.
Reference voltage check:
Connect DMM+ to TPA6 on board L, DMM– to TPA3 on board A.
Check DMM (V) = 2.48 to 2.60V.

Software calibration procedures

1. **Measurement offset calibration**

Short the module's input terminals of +, –.
Press A/B and STATIC/DYNA simultaneously over one second to let the module go to calibration mode.

The module displays:

LoFFS	<<– offset calibration of low range voltage
XXXX	xxxx: offset data of low range voltage measurement

Press LOAD, wait two seconds, and check the module's display:

HoFFS XXXX	<<– offset calibration of high range voltage xxxx: offset data of high range voltage measurement

Press LOAD, wait two seconds, and check the module's display:

LoFFS XXXX	<<– offset calibration of low range current xxxx: offset data of low range current measurement

Press LOAD wait two seconds, and check the module's display:

HoFFS XXXX	<<– offset calibration of high range current xxxx: offset data of high range current measurement

Remove input terminals' short circuit.

2. Voltage measurement full-scale calibration

Press LOAD and the module displays:

```
2.FS
uL
```

Set the DC source to 125V/0.1A, and apply DC source to the load module's input terminals.

Press LOAD and the module displays:

```
AAAAA
BBBBB
```

AAAAA represents the load module's voltage measurement before calibration.

BBBBB represents the load module's voltage measurement after calibration.

Adjust the knob of the module until DMM (V) reading = BBBBB ± 1 count.

Press LOAD and the module displays:

```
SAvE
```

Save the low range full-scale data.

Press LOAD and the module displays:

```
3.FS
uH
```

Set the DC source to 500V/0.1A.
Press LOAD and the module displays:

```
CCCCC
DDDDD
```

CCCCC represents the load module's voltage measurement before calibration.
DDDDD represents the load module's voltage measurement after calibration.
Adjust the knob of the module until DMM (V) reading = DDDDD ± 1 count.
Press LOAD and the module displays:

```
SAvE
```

Save the high range full-scale data.

2. Current measurement calibration

Press LOAD and the module displays:

```
4.FS
AL
```

Set the DC source to 5V/2A and current shunt range to 2A.
Press LOAD and the module displays:

```
EEEEE
FFFFF
```

EEEEE represents the load module's current measurement before calibration.
FFFFF represents the load module's current measurement after calibration.
Adjust the knob of the module until shunt current = FFFFF ± 1 count.

Press LOAD and the module displays:

```
SAvE
```

Save CCL measurement data.

Press LOAD and the module displays:

```
5.FS
AH
```

Set the DC source to 5V/21A and current shunt range to 20A.

Press LOAD and the module displays:

```
GGGGG
HHHHH
```

GGGGG represents the load module's current measurement before calibration.
HHHHH represents the load module's current measurement after calibration.
Adjust the knob of the module until shunt current = HHHHH ± 1 count.
Press LOAD and the module displays:

```
SAvE
```

Save CCH measurement data.

3. Current setting offset calibration

Set the DC source to 5V/20mA and current shunt range to 20mA.
Press LOAD and the module displays:

```
6.oFF
CCL
```

Press LOAD and the module displays:

```
KKKKK
```

Adjust the knob of the module until shunt current = 0 to 1mA.

Press LOAD and the module displays:

SAvE

Save setting offset data.

Press LOAD and the module displays:

7.oFF
CCH

Press LOAD and the module displays:

LLLLL

Adjust the knob of the module until shunt current = 0 to 5mA.

Press LOAD and the module displays:

SAvE

Save CCH offset data.

4. Current setting calibration

Set the DC source to 5V/2A and current shunt range to 2A.

Press LOAD and the module displays:

8.FS
CCL

Press LOAD and the module displays:

1.8000
PPPPP

1.8000 represents the load module's current setting before calibration.
PPPPP represents the load module's current setting after calibration.
Adjust the knob of the module until shunt current = PPPPP ± 1 count.
Press LOAD and the module displays:

```
SAvE
```

Save CCL setting data.

Set the DC source to 5V/20A and current shunt range to 20A.
Press LOAD and the module displays:

```
9.FS
CCH
```

Press LOAD and the module displays:

```
18.000
RRRRR
```

18.000 represents the load module's current setting before calibration.
RRRRR represents the load module's current setting after calibration.
Adjust the knob of the module until shunt current = RRRRR ± 1 count.
Press LOAD and the module displays:

```
SAvE
```

Save CCH setting data.

6. CR mode calibration

Set the DC source to 20V/10A and current shunt range to 20A.
Press LOAD and the module displays:

```
10.FS
CrL
```

Press LOAD and the module displays:

```
2.5000
SSSSS
```

2.5000 represents the load module's resistance setting before calibration.
SSSSS represents the load module's resistance setting after calibration.
Adjust the knob of the module until DMM (V) reading/shunt current = SSSSS (ohms) ± 1 count.

Press LOAD and the module displays:

```
SAvE
```

Save CRL setting data.

Press LOAD and the module displays:

```
11.FS
CrH
```

Set the DC source to 50V/2A and current shunt range to 2A.

Press LOAD and the module displays:

```
10.000
TTTTT
```

10.000 represents the load module's resistance setting before calibration.
TTTTT represents the load module's resistance setting after calibration.
Note: Because of the module's display limitation, the resistance setting is 100 ohms, not

10 ohms. Adjust the knob of the module until DMM (V) reading/shunt current = TTTTT (ohms) ± 1 count.

Press LOAD and the module displays:

```
SavE
```

Save CRH setting data.

7. CV mode calibration

Set the DC source to 500V/0.1A.

Press LOAD and the module displays:

```
12.FS
Cu
```

Press LOAD and the module displays:

```
475.00
UUUUU
```

475.00 represents the load module's CV voltage setting before calibration.

UUUUU represents the load module's CV voltage setting after calibration.

Adjust the knob of the module until DMM (V) reading = UUUUU ± 1 count.

Press LOAD and the module displays:

```
SAvE
```

Save CV setting data.

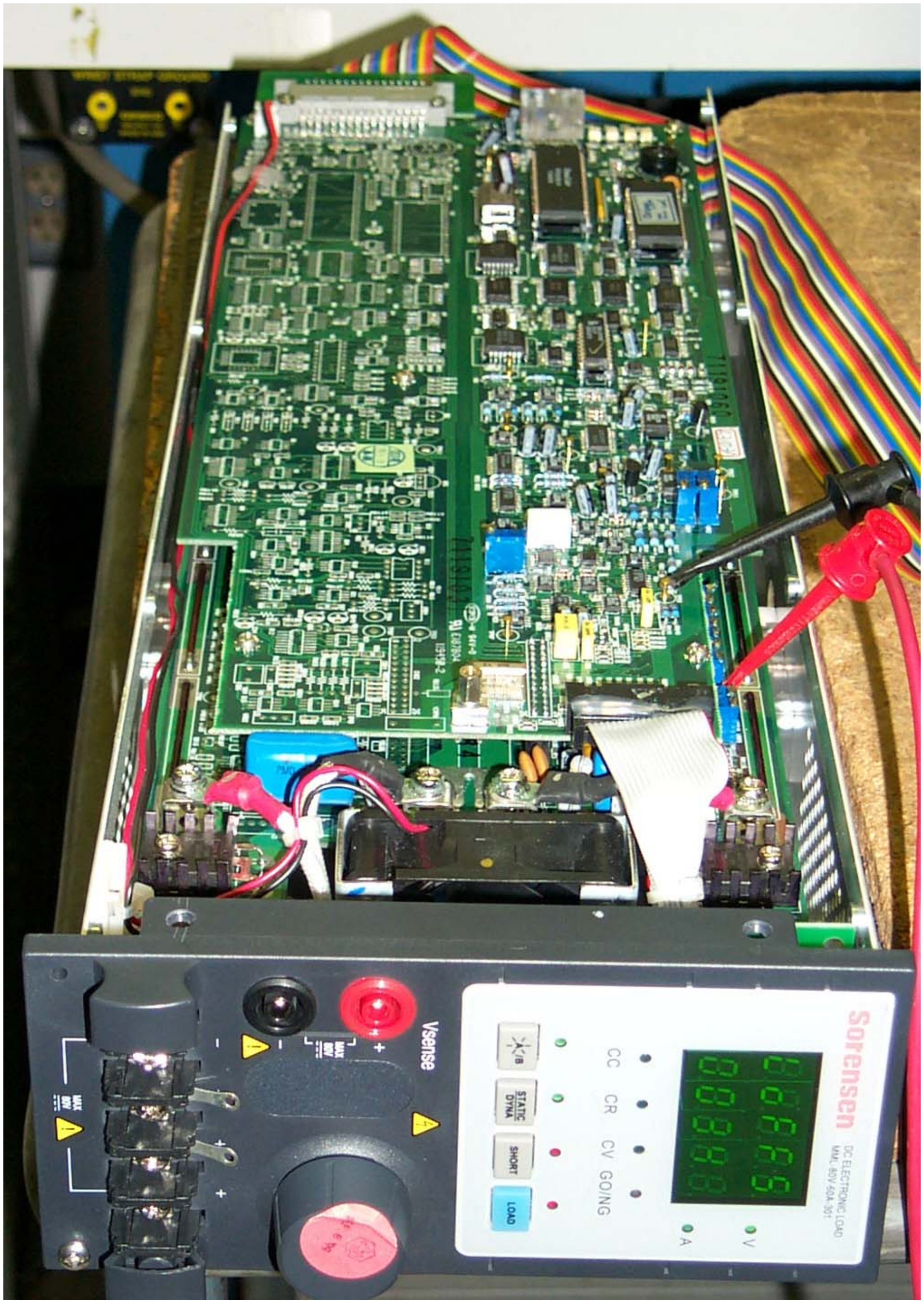
Recycle the power switch after calibration.

7.9 Removing Load Modules

CAUTION

This assembly contains static sensitive components. Observe all standard electro-static procedures when removing or replacing the GPIB board.

1. Disconnect all wires connected to the front of the module.
2. Remove the two screws securing the module, and pull out the module by holding the load connector.
3. Place the module on the workbench.
4. Remove the eight screws on the top and bottom sides, and the three screws on the left side. Then, remove the module's cover.


Vsense
Sorensen
CC
CR
CV
GO/NG
STATIC DYNA
SHORT
LOAD
A
V