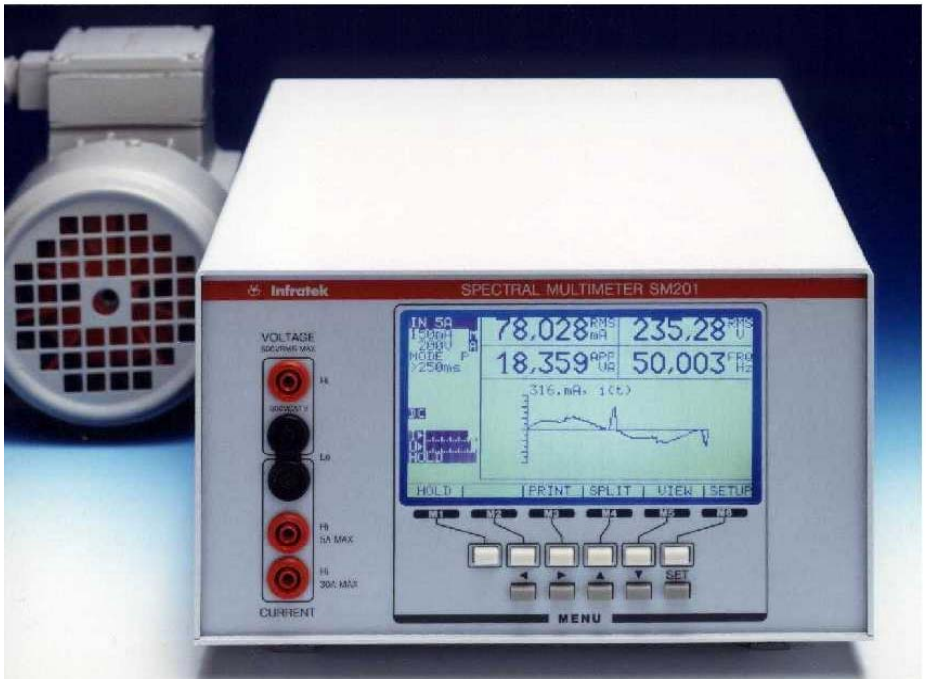
USERS MANUAL SM201

SPECTRAL MULTIMETER



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1. SAFETY

Before using the Spectral Multimeter, read the following safety information carefully. In this manual **„WARNING“** is reserved for conditions that pose hazards to the user; **„CAUTION“** is reserved for conditions that may damage your instrument.

- Avoid working alone.
- Follow all safety procedures for equipment being tested.
- Inspect the test leads for damaged insulation.
- Be sure the Spectral Multimeter is in good operating condition.
- To avoid electrical shock, use caution when working above 30V dc or rms.
- Disconnect the live test leads before disconnecting the common test leads.
- When making a current- or power measurement, turn the circuit power off before connecting the Spectral Multimeter in the circuit.
- Switching on inductive loads means large inrush currents. Take precautions to avoid overloading the current channel by shorting the start-up currents accross the current input.
- Switching off inductive loads or switching on rotating loads means large voltages or extremely fast changing voltages on the Spectral Multimeter input terminals. Such conditions may damage the instrument and are potentially hazardous.
- To comply with EN50081-1 the current- and voltage test leads must form 4 windings through ferrite torroid Philips Type 4322 020 9720 or equivalent. Interface inputs/outputs must be shielded.
- 1kV burst test: use shielded input- and output cables.
- The Spectral Multimeter complies with the safety standards IEC 1010-1, EN 61010-1.

1.1. WARNINGS

- Before reading the manual or before using this instrument read carefully the warnings below and make sure you understand them.
- **WARNING: Line Power**
  To avoid shock hazard, connect the instrument power cord to a power receptacle with earth ground.
- **WARNING**
  The maximum floating voltage above earth ground on the current input terminals and the voltage Lo-input terminals is 600V. Exceeding these limits poses a hazard to the meter and operator.
- **WARNING**
  This instrument must be operated by qualified personnel.
- **WARNING**
  Refer all servicing of this instrument to qualified personnel. Before opening case disconnect all leads connected to the instrument and finally disconnect the power line cord.
- **WARNING**
  The specifications given in this manual solely describe the technical properties of the instrument. They do not imply any other properties unless it is explicitly said so.
- **WARNING**
  Use of this instrument in life support systems and in systems for people transportation must be expressly authorized.
  The authorization must be signed by the manufacturer of this instrument.

2. INTRODUCING THE SPECTRAL MULTIMETER

WARNING

Read the „Spectral Multimeter Safety“ in section 1 of this manual before using the instrument.
This instrument is designed for bench-top, field service, and system application.
Some features provided by the Spectral Multimeter are:

- Large, blue LCD monitor, 120 x 64mm (240x128 pixels).
- Fully menu controlled operation with only 11 membrane keys.
- Meter mode and graphics mode.
- Measures and computes all electrical quantities of current, voltage, power, energy and harmonics of current, voltage, and power simultaneously.
- Frequency measurement 0.1Hz-100kHz.
- AC, and AC+DC for individual quantities.
- Built-in integrator.
- Harmonic Analysis of current, voltage and power, including IEC555-2.
- Bar graph and wave form display.
- Wide voltage- and current range (15mA-40A).
- High common mode rejection ratio.
- Flicker measurement, SM201 complies with IEC868.
- Measures current- and voltage bursts.

2.1. OPTIONS AND ACCESSORIES

Six option packages are available. Options 01 through 03 can be installed at the factory or by the customer on site. Option 04 and 08 must be installed at the factory.

- **Option 01** contains the RS-232 serial interface and the Centronics printer output.
- **Option 02** contains the RS-232 serial interface, the Centronics printer output, and the IEEE-488 interface. The IEEE-488 interface complies with the 488.1 and the 488.2 (1987) standard.

- **Option 03** contains the RS-232 serial interface, the Centronics printer output, the IEEE-488 interface, four programmable ±5V analog outputs, and eight analog inputs.
- **Option 04** contains a current sensor module supplied by the SM201. Current ranges are: 0-25A up to 0-1000A.
- **Option 07** contains an operating software under Windows.
- **Option 08** contains an external TTL-input for synchronization.

Available accessories are described below.

ACS1A: Current clamp with connector to the shunt input of the Spectral Multimeter; range 0-400A, DC-1kHz, 2 % accuracy.

ACS1B: Current clamp 0-20A and 0-200A, 1 %, DC-10kHz.

ACS2: Portable printer (106 x 180 x 88mm) with Centronics interface.

ACS3: Soft carrying case provides protection for the instrument. Ideally suited for service applications.

ACS4: Set of test leads, max. 32A, 1.5m; 2 red, 2 black.

ACS5: Shunt input connector.

ACS6: Service Manual.

ACS7: Rack Mounting Kit.

2.2. SPECIFICATIONS

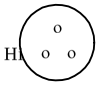
This section defines the performance of the Spectral Multimeter SM201. The user must be aware that exposure of the SM201 inputs to their maximum value for a prolonged time will result in additional measurement errors. These errors add to those given in the specification table.

5A input:	(I^2 x 0.004 %/A^2)	for t > 1 minute per 10 minutes
30A input:	(I^2 x 0.0002 %/A^2)	for t > 1 minute per 10 minutes
voltage input:	(U^2 x 0.0000003 %/V^2)	for t > 1 minute per 10 minutes.

Operating the 5A input at elevated currents (>4A) will also affect the 30A input, and visa versa.
Operating temperature range:15°C - 30°C

SPECIFICATIONS

Voltage	Ranges, 8 ranges 2-6-20-sequence; 0.6 V, 2V, 6V, 20V, 60V, 200V, 600V, 2000V.		
	Frequency range		DC, 2Hz-300kHz
	Crest Factor 4:1 at 50 % full scale (fs)	Common Mode 50Hz/100kHz	155dB/95dB
	Input Impedance		>2.3MΩ
	Standard accuracy 23° ±3°K; rms, mean, rectified mean; for 0.6V range typical. 1Hz-1kHz ±(0.1 % rdg + 0.1 % range) DC, 1kHz-10kHz ±(0.2 % rdg + 0.2 % range + 0.04 %/kHz rdg), DC typical 10kHz-100kHz, ±(0.3 % range + 0.04 %/kHz rdg) 100kHz-300kHz ±(0.3 % range + 0.04 %/kHz rdg), typical		improved accuracy, 1Hz-400Hz ±(0.05 % rdg + 0.07 % range)
Current	Ranges, 12 ranges 1-3-10-sequence; 15mA, 50mA, 150mA, 500mA, 1.5, 5, 15A, 1, 3, 10, 30, 100A.		
	Frequency range		DC, 2Hz-300kHz
	Crest Factor 4:1 at 50 % full scale (fs)	Common Mode 50Hz/100kHz	160dB/120dB
	Standard accuracy 23° ±3°K 1Hz-1kHz DC, 1kHz-10kHz 10kHz-100kHz 100kHz-300kHz	5A-/Shunt input[1] ±(0.1 % rdg + 0.1 % range) ±(0.2 % rdg + 0.2 % range) ±(0.3 % range + 0.04 %/kHz rdg) ±(0.3 % range + 0.04 %/kHz rdg), typical	30A input[1] ±(0.1 % rdg + 0.1 % range) ±(0.9 % rdg + 0.2 % range) ±(0.3 % range + 0.5 %/kHz rdg)	improved accuracy 1Hz-400Hz ±(0.05 % rdg + 0.07 % range) DC typical [1] For 2 lowest ranges, input >50 % fs
Power	80 ranges corresponding to the products V x A .		
	Frequency range of fundamental frequency		20Hz-1kHz
	Accuracy 23° ±3°K 20Hz-100Hz 100Hz-200Hz 200Hz-1kHz	 0.3 % rdg + (0.3 % + 1 % sinφ) range 0.5 % rdg + (0.5 % + 2 % sinφ) range 0.5 % rdg + (0.5 % + 0.2 %/100Hz) range, typical	 -80°< φ <80° -80°< φ <80° PF=1
Frequency	2Hz-100kHz, A or V triggered; Accuracy ±0.1 %.		100 % full scale

Computed Values	Accuracy; Reactive Power, Var = $\pm(VA^2 - W^2)^{1/2}$; Apparent Power: VA = Arms Vrms; Power Factor: PF = W/VA; Crest Factor: CF = Ap/Arms, Vp/Vrms; Form Factor: FF = At/Arms, Vt/Vrms; Impedance: Z = Vrms/Arms; Total Harm Dist: THD = $(Irms^2 - IFund^2)^{1/2}$/Irms, Flicker, Pst, Plt	Add accuracy percentage figures of values involved in computation.
Integrator	Energy, Accuracy 50Hz Wh, VAh, Varh; Basic accuracy of integrated quantity.	>1s measurement time.
Harmonic Analysis	Frequency range of fundamental 5Hz-60kHz	
	Range of harmonic	1-63
	Accuracy, Harmonic current and voltage 5Hz-1kHz ±(0.2 % rdg + 0.1 % range) 1kHz-10kHz ±(0.5 % rdg + 0.5 % range) 10kHz-60kHz ±(0.7 % range + 0.1 %/kHz rdg), typical	Computed values: Harmonic power, Harmonic phase angle (power factor), Harmonic impedance
Burst	Measures current- or voltage burst of an intermittent signal.	Minimum burst duration 1ms.
Flicker	Determines short time flicker Pst and long time flicker Plt. Use 0.5 sec. measurement time.	
Display	Blue liquid crystal graphic display with FL back light 64 x 120mm; 128 x 240 pixels	
Power	AC, 50-400Hz; Fuse: Power 18W.	85V-240V; 2AF/20VA
Dielectric Strength	Inputs to case or power supply Line input to case	2.5kV/50Hz/1 minute 1.5kV/50Hz/1 minute
Dimension	H x W x D; Weight	150 x 235 x 320mm; 4kg
Options	IEEE-488-2, RS232, Centronics printer output 4 Analog outputs, Output impedance 100Ω; accuracy 0.2 % 4 Analog inputs, low range, input impedance 200kΩ; accuracy 0.4 % typical 4 Analog inputs, high range, input impedance 200kΩ; accuracy 0.4 % typical Rack mounting kit; Humidity: KYG according to DIN 40040, max. 85 % RH non-condensing.	 0 - ±5V 0 - ±1V 0 - ±10V
Shunt Input	 open circuit Ranges in mV: 60, 60√10, 600, 600√10, 6000, 6000√10 Accuracy: Same as 5A-input Input impedance: 200k; input of 60mV corresponds to 1.0000A display.	

3. MATHEMATICAL DEFINITIONS USED BY THE SPECTRAL MULTIMETER

NOTE: RMS-, rectified mean-, mean-, maximum-, minimum-, and peak-to-peak value apply to current and voltage.
Energies apply to real-, apparent-, and reactive power. Charge applies to rectified mean current only.
Total harmonic distortion applies to current and voltage. Flicker applies to voltage only.

RMS-value	$(1/T \int_o^T i^2\, dt)^{1/2}$
Rectified mean	$1/T \int_o^T \lvert i \rvert\, dt$
Mean value	$1/T \int_o^T i\, dt$
Maximum	max. (i) in averaging interval
Minimum	min. (i) in averaging interval
Peak-to-peak	max. (i) - min. (i) in averaging interval
Average Power P	$1/T \int_o^T u\ i\ dt$
Apparent Power S	RMS current x RMS voltage
Reactive Power Q	$\pm(S^2 - P^2)^{1/2}$ for every harmonic
Crest Factor	Maximum / RMS-value
Form Factor	RMS-value / Rectified mean value
Frequency	Number of zero crossings of current or voltage.
Power Factor	P/S
Energies, Charge	$\int_0^t xdt$ x=P, S, Q, rect. mean current
Total harm. Distortion THD	$(Irms^2 - Ifund^2)^{1/2}/Irms$
Impedance	Vn/In ⌊phase n=harmonic 1-63
Short time Flicker	P_{st} (10 minutes), P_{S3} (3 minutes), P_{S1} (1 minute)
Long time Flicker	P_{lt}
Burst duration	B_dur

4. GETTING STARTED

This section explains how to prepare the Spectral Multimeter for operation, discusses general operating features, and explains some common measurements.

4.1. FRONT PANEL AND REAR PANEL

The front panel in figure 4.1 shows the display monitor in the center and below the display two rows of control keys. The top row contains the menu control keys and the bottom row contains the **Cursor** and **SET** control keys.
On the left hand side are the input terminals. At the top are the Hi and Lo voltage terminals. At the bottom are the current Lo, 5A, and 30A input terminals.

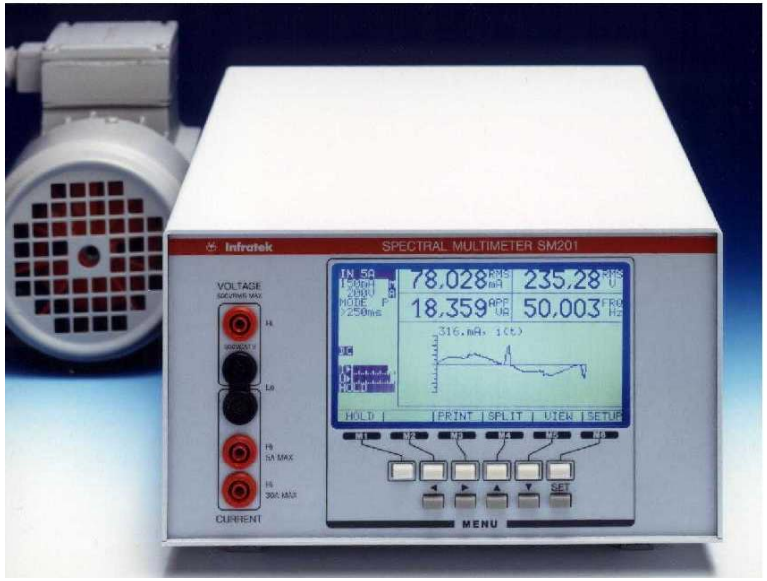


Fig. 4.1 Spectral Multimeter Front Panel

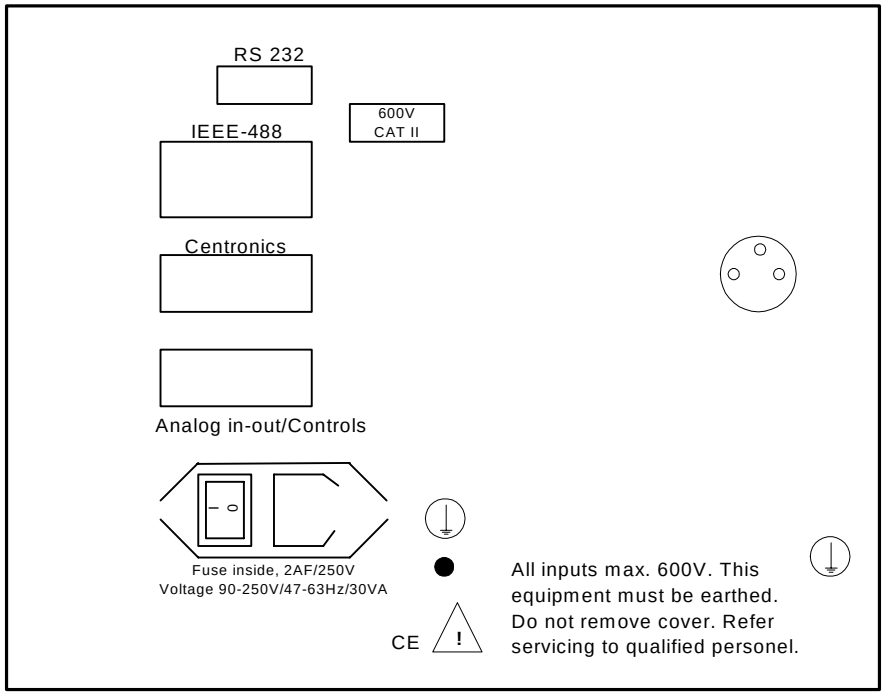


Figure 4.2. Spectral Multimeter Rear Panel

The rear panel shown in figure 4.2 contains the shunt input connector. When not in use, the short circuit connector must be installed.
On the left hand side of the rear panel are, from top to bottom, the RS-232 interface connector, the IEEE-488 interface connector, the centronics printer connector, and the analog in- and output connector.
To the far left is the power line cord connector for 50/60Hz line voltages in the range 85V to 265V.

4.2. ADJUSTING THE OPTIMAL VIEWING ANGLE

Operating the Spectral Multimeter on a table you may want to tilt the instrument. This can be done by rotating forward the stand-offs at the bottom plate.

4.3. LINE POWER

WARNING

To avoid shock hazard, connect the Spectral Multimeter line cord to a receptacle with earth ground.
Plug the line cord into the connector on the rear of the instrument. It will operate on any line voltage between 85V ac and 265V ac without adjustment, and any frequency between 50 and 400Hz.

4.4. TURNING THE SPECTRAL MULTIMETER ON

To turn the instrument on activate the power line switch located near the power receptacle on the rear panel.
When the instrument is turned on the display is set to its start-up configuration with all values set to zero for about 2 seconds while the instrument performs an internal self test. After this self test the instrument assumes its initial setting. The initial setting is determined by the instrument setting recall number 00 to 20. It is factory set to recall number 00 which assumes the following state:
The first line of the display number field shows the RMS current and the RMS voltage. The second line shows power and frequency of current, and the third line shows apparent power and power factor.
The fourth and fifth lines are graphic area. At start-up the harmonic bar graph of current is displayed. The horizontal scale is numbered referring to the harmonics of current (N=0 is the DC component) and the vertical scale gives the magnitudes of the harmonics of mA or A.

4.5 USING THE FUNCTION KEYS

The two key control fields below the display contain 11 keys. The top row is the menu control field and below is the cursor control field.
The basic use of the two key control fields is as follows:
The **cursor key control field** is used to move the cursor to the desired position on the display. Pressing the **SET-key** means that you want to modify this position; this can be a position to the very left of the display (annunciator field) such as 5A/30A input selection, or current range- or voltage range selection, or synchronisation to I or U (current or voltage of phase L1), or selection of averaging time or selection of measurement mode.
When you move the cursor to the display number field the display can be reconfigured, that is, you can place at the selected position a different quantity.

The **menu-key control field** consists of keys **M1** through **M6** and go with the 6 menus shown along the bottom of the display. These menus are dynamically changing, depending on the cursor position and other action you may take.

4.6. SELECTING A MEASUREMENT RANGE

When turning on the Spectral Multimeter the range selection is automatic. This is indicated by the range annunciators on the left hand side of the display, e.g. 1A **A** / 300mV **A**. To select the 5A- or 30A current input proceed as follows: Move the cursor to the **„IN 5A“** annunciator and press the **SET-key**. A pull down menu gives you 3 choices **IN 5A/IN 30A/SHUNT**. Now move the cursor to the 5A- or 30-A input annunciator and press the **SET-key**. The choice of current input depends on the maximum current flowing in your circuit to be measured.
The **A** at the end of the range annunciator indicates autoranging.
To select a current range move the cursor to the current range annunciator and press the **SET-key.** A pull-down menu of the possible ranges appears. Move the cursor to the desired range and press the **SET-key**. The range annunciator with the new range is now displayed and furthermore, the **M** indicates manual ranging for current.

WARNING

Make sure not to overload current inputs, damage may occur to the instrument. Make sure when wiring the Spectral Multimeter in a circuit that you are wiring the correct current input (5A or 30A) and make sure to select the correct input on the Spectral Multimeter front panel (IN 5A or IN 30A).

4.7. TAKING SOME BASIC MEASUREMENTS

WARNING

Read the Spectral Multimeter safety before operating this instrument.
The following procedures describe the basics of taking common measurements operating the Spectral Multimeter from the front panel. These procedures are provided for the user who needs to get started quickly.

WARNING

To avoid electrical shock or damage to the Spectral Multimeter, do not apply more than 850V peak between any terminal and earth ground.
The user should be well aware of the fact, that switching off inductive loads may generate extremely fast and high voltage transients exceeding above limits.
To measure voltage, current, power and related quantities in a circuit connect the test leads as shown in figure 4.3 and described below.

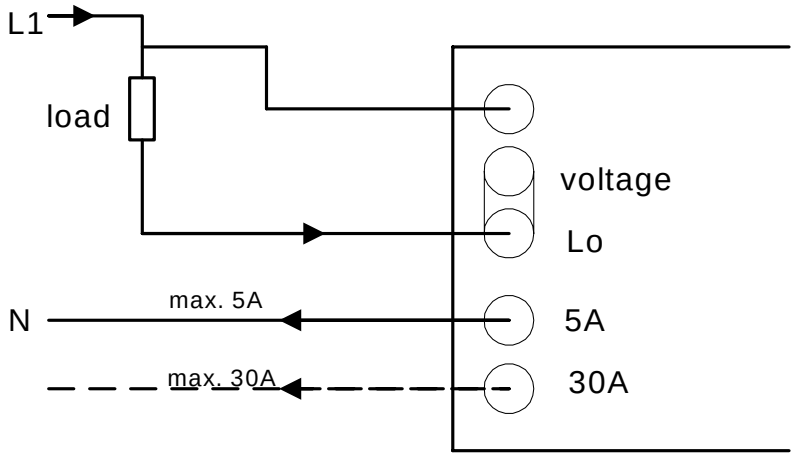


Fig. 4.3 Spectral Multimeter wiring in a single phase system

- Turn off power in the circuit to be measured.
- Break the circuit and connect phase L1 to the voltage input and current input as shown in figure 4.3.
- Switch on the Spectral Multimeter (it will start-up in automatic ranging and measuring Mode P). Select the correct current input **IN 5A** or **IN 30A** as described in 4.6.
- Turn on power to the load to be measured.
- The Spectral Multimeter will automatically select the voltage range and displays the following six electrical quantities (display top to bottom) RMS-current, RMS-voltage, power, frequency, apparent power, and power factor.
  The bar graph of current shows the harmonic content.
- Use the side menu to alter settings.

5. OPERATING THE SPECTRAL MULTIMETER FROM THE FRONT PANEL

This section explains how to operate the instrument from the front panel.

5.1. INTRODUCTION

This Spectral Multimeter is a very advanced measuring system, equipped with features not known to similar instruments. For example, you can select dc- or ac-coupling for individual quantities, you can choose those quantities you want to integrate, you can combine meter mode and graphics mode, you can obtain harmonic analysis while the Spectral Multimeter is running in the meter mode. You can select from six different measuring modes: Mode P, U, I; Burst U, I; and Flicker. In Mode P the Spectral Multimeter measures current and voltage simultaneously and also determines power when the fundamental frequency of the signal is in the range 20Hz-1kHz.

5.2. FRONT PANEL OPERATIONS

The following operations can be performed from the front panel:

- Select manual or automatic ranging.
- Select the 5A-, 30A-, or shunt input.
- Select a current or a voltage range.
- Select the measurement time.
- Select AC- or DC-coupling for individual quantities.
- Select integration for individual quantities.
- Select display configuration.
- Select the measuring mode.
- Select display **HOLD**.
- Select graphics mode.
- Select current- and voltage scaling.
- Select input- output configuration.
- Save instrument settings and set start-up instrument configuration.

5.3. CURRENT INPUT SELECTION

You have the choice of selecting one of three inputs 5A-, 30A-, and shunt input.

CAUTION

Due to different overload conditions of the current inputs you should, at all times, know which one of the inputs is in use.
If you are using the 5A input you must select the 5A input indicated by the input annunciator **IN 5A** or **IN 30A**. If it is not already selected proceed as follows: move the cursor to the input annunciator, press the **SET-key**. A pull-down menu appears for selection of the desired input. With cursor and **SET** you select the 5A current input. Now the current ranges are 15mA, 50mA, 150mA, 500mA, 1.5A, 5A, and 15A and the current display is scaled correctly.
Similarly, you select the 30A input with ranges 1A, 3A, 10A, 30A, and 100A.
Finally, selecting the current shunt input will set the input ranges to 60mV, 60mV√10, 600mV, 600mV√10, and 6V with a sensitivity of 1A/60mV. Using the scaling capabilities of the Spectral Multimeter will give you direct read out in ampere for your shunt or your current clamp (with voltage output).
For current harmonic measurements according to IEC1000-3-2 we recommend to use the 30A input. Its internal resistance is 4.7mOhm.

5.4. RANGE SELECTION / AUTO RANGE SELECTION

To select a current range move the cursor to the current range annunciator. Press the **SET-key**. A pull-down menu appears with the available ranges. Move now the cursor to the desired range and press the **SET-key** again to select that range. The current input is now in manual ranging indicated by the **M** in the range annunciator.
In similar manner a voltage range is selected. Once you have selected a current range the current input of the Spectral Multimeter is in manual ranging. You can bring it back to autoranging as follows: Move the cursor to the current range annunciator. The menu at the bottom of the display shows **„AUTO“.** If you press the menu control key **M2** the current range annunciator changes to **A** at its very end indicating autoranging.
Similarly you proceed to set the voltage input to autoranging.

5.5. SELECTING MEASURING MODE

The Spectral Multimeter is equipped with a voltage input, two current inputs (0-5A and 0-30A) and a shunt or current clamp input to cover almost any current range (0-5A and 0-30A) and a shunt or current clamp input to cover almost any current range (lowest range is 15mA). You are allowed to simultaneously connect a voltage signal and a current signal to the instrument as long as the two signals have one common node in the electric circuit. The common node must be connected to the SM201 Lo-terminals. Move the cursor in the side menu to **MODE** and press **SET**. A pull-down side menu displays the available measuring modes:

- MODE P
- MODE I
- MODE U
- BURST I
- BURST U
- FLICKER

Select MODE P if you want complete signal information in your test circuit and if you have both current and voltage applied to the Spectral Multimeter. This very unique measuring mode can be used when the fundamental frequency of the applied current is in the range 20Hz to 1kHz. The SM201 determines all available quantities on current (also IEC555-2) and voltage including harmonics, impedance, and phase angle between current and voltage of every harmonic. A novel measuring technique allows the computation of active-, apparent-, and reactive power, power factor, harmonics of power, and energies (active, apparent, reactive).

Select MODE I if you want signal information on current only. All available quantities pertaining to current including harmonics and charge (integration of rectified mean current) are available.

Select MODE U if you want signal information on voltage only. All available quantities pertaining to voltage are determined.

Select BURST I or **BURST U** if you want to measure the rms-value of a current burst or a voltage burst. A typical application could be the measurement of a current burst in a welding process. A minimal burst duration of 1ms is acceptable. At all times you must use manual ranging and you must select a suitable range. For more information on various measurements refer to the end of section 5 of this manual. By selecting B_dur from the display selection table the duration of a burst is displayed (1ms up to 10s).

Select **FLICKER** if you want to run a precompliance test on your equipment regarding flicker according to IEC555-3 / IEC1000-3-3 / EN61000-3-3.
The SM201 complies with the IEC report 868 to determine short time flicker P_{ST} and long time Flicker P_{LT}. P_{ST} is determined in 10 minute intervals and its value is displayed if you have selected P_{ST} and P_{LT} as one of the display values. P_{LT} is updated every 10 minutes and can run as long as 5300 hours. Always use 0.5 sec measuring time for flicker measurements.
For a quick flicker result you can select P_{S1} (1 minute) or P_{S3} (3 minutes) flicker quantities. Only one short time flicker value must be displayed at a time. Long time flicker is update when a new short time flicker value is available (1 minute, 3 minutes, or 10 minutes).
Prior to a flicker measurement we recommend to reset P_{ST} and P_{LT} to zero. This reset function is combined with the energy reset. Therefore, you should display an energy value in a number field. To **RESET FLICKER** (and energy) move the cursor to the energy value and press the **RESET**-key to set P_{ST} and P_{LT} to zero.

5.6. SELECTING THE MEASUREMENT TIME

The measurement time sets the minimum time for signal averaging as well as the time for display update. It can be varied from 100ms, 250ms, 500ms, 1s, 2s, 5s, and IEC555-2. For frequencies below 10Hz use 1s measurement time.Furthermore, this averaging time is expanded to the end of the next signal period. This results in stable readings down to 2Hz. To select the measurement time move the cursor to the measurement time annunciator and press the **SET-key**.
The pull-down menu gives you seven choices. Select the one you need by moving the cursor to the desired position. Press the **SET-key** to select the desired measurement time.
Selecting the measurement time IEC555-2 (measuring Mode I) current harmonics are determined according to IEC1000-3-2 / EN61000-3-2. Current harmonics are calculated from an FFT over 16 periods.

5.7. SELECTION OF AC- OR DC+AC-COUPLING

Coupling pertains to some, not all, measured quantities. AC-coupling is possible for the rms values, for active-, apparent-, and reactive power, and for power factor.
Move the cursor to the quantity you want to change the coupling, e.g. rms current. The menu at the bottom of the display shows AC/DC and an annunciator **DC+AC** or **AC** on the left side of the display indicates the presently set coupling for the selected measurement value. The second menu key **M2** toggles the coupling from **DC+AC** to **AC** and vise versa.
Selecting **AC** means that this measurement value is without a possible dc-component and **DC+AC** coupling means it is including the dc-component.

5.8. CHANGING THE DISPLAY CONFIGURATION

You have the choice of selecting 8 current values: rms, mean, rectified mean, crest factor, minimum, maximum, peak-to-peak, and form factor. 8 values four voltage, four power related quantities, frequency, three energies, charge, and harmonics of current , voltage, and power.
Any one of these measured values you can place at any location on the display. We recommend to place the most important quantities at the top of the display.
This is how you modify the display, at one place, for example, the quantity at the bottom of the first column.
Move the cursor to this location and press the **SET-key**. A table appears in which you can select the quantity of your choice by moving the cursor to this position in the table. Press the **SET-key** to place the new quantity on the display.

5.8.1. CHANGING THE HARMONIC NUMBER

When you have a harmonic value (current, voltage, or power) displayed in the display number field you can change its harmonic number from 1-63 in the following manner: Move the cursor to the position of the harmonic value. The harmonic annunciator h63 on the left of the display indicates the harmonic number.
The menus at the bottom of the display give you 4 choices to increment the harmonic number in steps ±1 and ±10. Together with display **HOLD** this is a convenient way to step through the harmonics.

5.9. MAIN MENU SELECTION

Move the cursor to the side menu on the left hand side of the display. The main menu
„**HOLD, AUTO, PRINT, SPLIT, VIEW, SETUP“** appears at the bottom of the display.

NOTE: **AUTO** is displayed only when the cursor is moved downwards to the current- or voltage range annunciator. **AUTO** applies to autoranging of current or voltage.
The menus are entered with the control keys **M1** through **M6**.

5.9.1. DISPLAY HOLD

The display update can be stopped by pressing the menu control key **M1.** The annunciator **HOLD** appears. A complete set of data from the latest measurement interval is stored. To resume the measurement update, press key **M1** again.
While the Spectral Multimeter is in **HOLD** you can inspect every measurement value by altering the number field, e.g. you can step through every harmonic value of current, voltage, or power; you can change the graphic area and view the harmonic bar graph of current, voltage, or power; or you can display the wave form of current or voltage.
It is important to note that the measurement process goes on in the background while the SM201 is in **HOLD**. This assures correct integration of energies and charge at all times.

5.9.2. AUTO RANGE SELECTION

The menu **AUTO** (M2) appears when the cursor in the annunciator field is moved to either the current- or the voltage range annunciator. To select current autoranging move the cursor to the current range annunciator and press the menu control key **M2**.
To select voltage autoranging move the cursor to the voltage range annunciator and press the menu control key **M2**.
NOTE: The Spectral Multimeter monitors current or voltage transients of less than 1µs duration. As a consequence, occasional current- or voltage peaks cause undesired range changes or lead to race conditions. In such cases use manual ranging.

5.9.3. SELECTING THE SIZE OF THE GRAPHIC AREA

The number field and the graphic area of the Spectral Multimeter can be increased or decreased using the menu **SPLIT** (M4). Press the menu control key **M4** to enter the menu **„ESC, EXP, RED, , , ,“** which allows you now to alter the graphic area. With **EXP** (=expand) you can increase it and with **RED** (=reduce) you can decrease it. To return to the main menu press **M1** (ESC).

5.9.4. SELECTING THE GRAPHIC DATA

The menu **VIEW** is selected by pressing the menu control key **M5**. The graphics selection menu **„ESC, FFTi, FFTu, FFTp, i(t), u(t)“** is entered. It allows you to choose graphics data by pressing the menu control keys **M2** through **M6**. In all bar graphs approximate harmonic peak values are displayed (not rms values).

Menu **FFTi:** Pressing the menu control **M2** selects the harmonic bar graph of current.
(**Note:** The size of the graphic area can be changed at any time.) The horizontal axis shows the harmonic numbers from 0-63, N=zero being the DC-value and N=1 being the fundamental of the current. The vertical axis shows the magnitude of the harmonic currents. The top of the scale is given im mA or A written along the top of the graph. The scaling is done automatically and is dynamically adjusted to give optimum resolution.
NOTE: If you need more precise values of harmonic currents you can display them in the display number field and step through the range of harmonics (1 through 63). The harmonics displayed in the display number fields are rms values.

Menu **FFTu**: Press the menu control **M3** to display the harmonic voltage bar graph. The horizontal axis shows the harmonic numbers 0-63 and the vertical axis indicates the magnitude of the voltage harmonic in mV or V. The scaling of the vertical axis is done automatically and is adjusted for optimum resolution.

Menu **FFTp:** Press the control **M4** to display the harmonic power bar graph. The horizontal axis is moved to the middle of the graph to allow for positive and negative power harmonics. A negative power harmonics results, when the phase angle of the corresponding voltage- and current harmonic is larger than ±90°.
The harmonic numbers 0-63 are indicated at the bottom of the graph.

Menu **i(t):** The wave form display of current can be selected with the control key **M5**. In the frequency range 5Hz to 1600Hz the graph shows one cycle and above 1600Hz eight cycles. The time base is given by the frequency indication in the display number field. The top of the vertical axis is given in mA or A and is automatically scaled.

Menu **u(t):** Finally, the wave form display of voltage can be selected by pressing the control key **M6**. In the frequency range 5Hz to 1600Hz one cycle is displayed 1600Hz eight cycles. The time base is given by the frequency indication in the display number field, e.g. the frequency indication shows 100.0Hz then one cycle corresponds to 10ms. The vertical axis is automatically scaled and the top of the scale is given in mV or V.

5.10. SHORT TIME INTEGRATOR

The following quantities can be integrated for the duration of the selected measurement time: real-, apparent-, and reactive power, and rectified mean current. The resulting values are energy in Wh, apparent energy in VAh, reactive energy in Varh, and charge in Ah. The sign of the quantity to be integrated is taken into account, that is, the displayed energy can be negative.
This is how you activate the short time integrator for a specific quantity, let's say, for active power. Move the cursor to active power display field and press **SET**.
The third menu along the bottom edge of the display shows σ dt indicating that active power is one of the quantities that can be integrated. When you press now **M3** the σannunciator appears next to the
DC/AC-annunciator or, if it was selected before σ, it disappears. The σ annunciator indicates that power is integrated for the duration of the selected measurement time.
For long time energy computation refer to the section **ENERGY COMPUTATION**.

5.11. ENERGY COMPUTATION AT 50HZ

The SM201 allows long time energy computation of real-, apparent- and reactive power and charge computation using rectified mean current. In the **HOLD** mode the display values are held and the energy computation is stopped. Range changes during the measurement are allowed and do not influence the result, accumulation over a period of more than 10 years is possible. The resolution goes from **nWh** to **MWh**. Scaling of current and voltage are correctly taken into account.

5.11.1. SET-UP FOR ENERGY MEASUREMENT

Let us assume all the energies need to be determined. Move the cursor to the number field where you want to place active energy. Press **SET**; the selection table is presented. Move the cursor now to **ENERGY** and press the **SET-key** again. By this time you are back in the number field. The menu at the bottom of the display shows „**HOLD, ACT, APP, REA, RESET, ,"** and gives you

the choice of active-, apparent-, and reactive power. To place active power in this number field press **M2**, the annunciator **ACT** in the annunciator field indicates the type of energy.
Similarly you proceed to place apparent energy in another number field, that is, move the cursor to this field, press the **SET-key** and select **ENERGY**, press **SET** again to come back to the number field, and finally press **M3** to select apparent energy.
In a similar manner reactive energy is set-up. Note that the accumulated values are indicated by **ACC.**

5.11.2. SET-UP FOR CHARGE MEASUREMENT

Charge is determined by integrating the rectified mean value of current. So far we have set up 3 energy values. Let's put the value of charge to a fourth number field as follows: move the cursor to this number field. Press the **SET-key** move the cursor to **RECT** of current, press the **SET-key** again to have the rectified mean current displayed in this number field. The menu at the bottom shows **„HOLD, , σdt, RESET, , ,".** Pressing **M3** once you select short time integration, press **M3** again to select the desired longtime charge accumulation. The annunciator shows **A**, meaning charge accumulation and the units in the number field are **Ah**.

5.11.3. RESETTING, STARTING, AND STOPPING

This is how you reset the energy values. Move the cursor to a number field displaying energy. Press **RESET (M5)**. Before starting a measurement energy and charge values are normally reset to zero. All three energy values can be reset together, charge reset is separate. With the reset of the energies are also reset the **FLICKER** values.
This is how you can proceed. Bring the Spectral Multimeter to **HOLD** and reset energy- and charge values. Press **HOLD** to start the measurement and press **HOLD** again to stop it.

5.12. SCALING OF CURRENT- AND VOLTAGE INPUTS

When the Spectral Multimeter starts up it's current- and voltage scaling factors are set to 1.0. When you are using any kind of transducer or current transformer you can scale the inputs to have actual current-, voltage-, and power values displayed.
To change the scaling factors enter the **SETUP** menu. Move the cursor to the scaling factor you want to change. Let's assume you want to change the current scaling factor to 250. Press **SET**. At this point you can modify single digits with the up- and down arrows. Move the cursor to the first digit and set it to 2, move the cursor one digit to the right and set it to 5, and finally modify the exponent to 02 and press SET to store the selected factor. The new scaling factor looks like this:

Scale I +2.499999e02

which is very close to 250 for all practical purposes.

5.13. PRINTING DATA

In the main menu mode key **M3** activates printing of all display values. A printer with Centronics Interface that does not need any software setting can be used. This way you can print up to 10 different values. Option 01, 02, or 03 must be installed.

5.14. SAVING YOUR PERSONAL INSTRUMENT SETTING

The SM201 lets you store 20 different instrument settings including interface parameters and allows you to program the desired start-up configuration.

WARNING: Disconnect all inputs and interface connections to the instrument before you perform the procedures described in sections 5.14.1. and 5.14.2. Failure to do so may result in erroneous setup data stored in nonvolatile memory. This in turn may lead to serious start-up problems.

5.14.1. THIS IS HOW YOU SAVE YOUR DESIRED INSTRUMENT SETTING

First you configure the display area and the graphics area. Select the current input, select the desired ranges or select auto-ranging, select the measurement time, and the synchronization.
Select the attributes of the displayed quantities such as AC- or DC-coupling, or integration.
Also configure the RS-232-, the IEEE-488 interface, and set the scaling factors. To save the complete setting under setting number 12 you proceed by selecting the SETUP menu (M6). Move the cursor to “Setup Save No 00”. Press the SET key to advance the save number. When set to 12 press **ESCape** (M1). This will store the complete instrument setting under setting number 12. Valid “Setup Save No” are: 01, 02, ... 19, 20.

5.14.2. THIS IS HOW THE SM201 STARTS UP IN THE DESIRED CONFIGURATION

The default start up No is 00. To have a start up under No 12 you proceed as follows: Enter the SETUP menu (M6). Move the cursor to “Setup Recall No 00” and press SET to advance the recall number to 12. Press **ESCape (M1**). From now on the SM201 starts up in the saved configuration 12. You can always go back to the default startup by selecting “Startup No 00”. Valid “Setup Recall No” are 00, 01, ... 19, 20.

Exception: From the four Flicker values P_{St}, P_{S1}, P_{S3}, and P_{lt} only P_{St} and P_{lt} should be used if storage in nonvolatile memory is desired.

5.15. MEASUREMENT TECHNIQUES USING THE SPECTRAL MULTIMETER

This section gives you an overview how the SM201 can work for you.

6. OPERATING THE SPECTRAL MULTIMETER USING THE COMPUTER INTERFACE

6.1. INTRODUCTION

The Spectral Multimeter can be operated from a host by sending commands to it through a computer interface on the rear panel.
Section 6 describes how to set up, configure, and operate the Spectral Multimeter via the RS-232 or the IEEE-488 interface.
With the IEEE-488 interface the instrument is fully programmable for use on the IEEE standard 488.1 interface bus and also complies with the supplemental standard 488.2.

6.2. LOCAL AND REMOTE OPERATIONS

When the Spectral Multimeter is operated from a host then it is operated „remotely“, when operated from its front panel the Spectral Multimeter is operated „locally“.
The Spectral Multimeter is no longer controllable from the front panel when via interface the **Local Lockout** state has been enabled.

6.3. COMPUTER INTERFACES

Your Spectral Multimeter can be equipped without interface, with RS-232 interface (Option 01), or with both RS-232 and IEEE-488 interface.
You can check in the **SETUP** menu which options you have installed. If an interface is not installed its parameters are marked n/a (not available).
Basically, you can operate both, the RS-232 and the IEEE-488 interface, simultaneously. Due to limited rear panel space you may have difficulties installing both interface connectors.

6.4. SETTING INTERFACE PARAMETERS

The Spectral Multimeter sets the parameters at startup to the following default values:

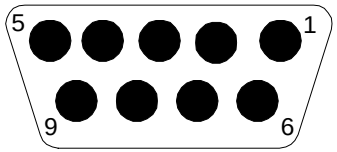
Band:	9600
Parity:	None
Terminator:	CR
Handshake:	None
IEEE-address:	1

Above parameters can be changed by entering the **SETUP** menu via the front panel or by sending commands through the computer interface. Interface settings can be stored in none-volatile

memory and are selected at start-up if the recall number is selected accordingly (section 5.14.). In order for the Spectral Multimeter and the host to communicate through the interface the communication parameters of the Spectral Multimeter must match those of the host.

6.5. CABLING THE SPECTRAL MULTIMETER TO A HOST

Turn Spectral Multimeter off. When cabling is complete turn power on again.
The RS-232 interface on the Spectral Multimeter rear panel uses a DB-9 connector. Its pinout is given below.



1	DCD	Data Carrier Detect
2	RxD	Received Data
3	TxD	Transmitted Data
4	DTR	Data Terminal Ready
5	Grd	Signal Ground
6	DSR	Data Set Ready
7	RTS	Request to Send
8	CTS	Clear To Send
9	RNG	Ring

Use a one-to-one connected (TxD and RxD not crossed) RS-232 cable. Its length should be less than 15m to make sure not to exceed the allowable (2000pF) cable capacitance.
To use the IEEE-488 interface cable the Spectral Multimeter to a host.
The IEEE-488 operation is governed by following limitations: a maximum of 15 devices can be connected in a single bus system; the maximum length of cable must be less than 20m or 2m times the number of devices in the system.

6.6. HOW THE SPECTRAL MULTIMETER PROCESSES INPUT

The Spectral Multimeter processes and executes valid input strings sent by the host. The input string is followed by an input terminator such as **CR/LF** (carriage return/line feed).
When the Spectral Multimeter receives input, it stores it in a 32 byte input buffer. As soon as the input terminators have been recognized the data in the buffer are processed.
The Spectral Multimeter accepts upper and lower case characters. If a command can not be understood, or it was longer than 32 characters which can not be the case for correct commands, the command will be ignored and an error will be generated.
For the RS-232 you can select the Xon hand shake modus. Xon signals the host to stop transmission when the input buffer of the Spectral Multimeter is full. If in this process information gets lost a device dependent error will be generated.

For the IEEE-488 the hold-off is set when the input buffer of the Spectral Multimeter is full. This stops data transmission instantly until space in the input buffer is made available.

6.6.1. INPUT TERMINATOR

An input terminator is a character or command (EO1, IEEE-488.1) sent by the host identifying the end of a string. Any of these terminators will be recognized as „end of message“.
Valid terminators for the RS-232 interface are:

CR (Carriage Retunr), **LF** (Line Feed)
CRLF (Carriage Return / Line Feed), and
LFCR (Line Feed / Carriage Return)

Valid terminators for the IEEE-488 interface are:

EOI (End or Identify) and any or none of the combinations with **CR** (Carriage return) and **LF** (Line Feed)

6.6.2. SENDING COMMANDS TO THE SPECTRAL MULTIMETER

Command	**Action**
VOLT:RMS:AC 1	AC-coupled rms voltage is displayed in display field 1 (fields are: 0 = top left, 1 = top right ... 9). The minimum required characters (upper case) are used.
voltage:rms:ac:?	Query form. To this command the Spectral Multimeter outputs (in scientific format) an alphanumeric string of the ac-coupled rms voltage. The maximum allowable characters in lower case are used.
CURR:SCALE 1.000eo	Sets the current scaling factor of the Spectral Multimeter to 1.
CURR:SCALE?	Query form. The Spectral Multimeter returns the current scaling factor in scientific format.
CURR:FFT?	Query form. The Spectral Multimeter returns the harmonics of current in the range specified by the FORMAT:START/END command.

Commands can be sent in upper or lower case characters. The upper case letters in the command set table are the minimal string to be sent, the lower case letters are optional.
No space is allowed except for the selector at the end of a command where a space is mandatory.

RULE 1: Every command must be closed by a terminator. The maximum length must not exceed 32 characters.

You can not pack two commands into one, an error would be generated.

RULE 2: Read Spectral Multimeter’s output only once for each query command.

The output buffer is cleared after it has been read. This prevents previously read data from being read a second time by mistake. A device dependent error is generated. (Query commands are identified by the „?“ at its end).

RULE 3: Read query responses before sending an other command string.

If you send a query without removing the old message from the query before the old message gets lost. A device dependent error is generated.

6.6.3. HOW THE SPECTRAL MULTIMETER PROCESSES OUTPUT

When the host sends a query command the Spectral Multimeter places an alphanumeric string into the output buffer. In case of the RS-232 interface, data are transmitted right away and are terminated with the set terminators (see RS232: terminator command). In case of the IEEE-488 interface the contents of the output buffer is transmitted after the Spectral Multimeter has been addressed as talker. The string is terminated with **CR, LF** accompanied with **EOI**.
The output from the Spectral Multimeter can be measurement data in scientific format. This can be a single string or, for a range of harmonics, 2 to 99 strings.

Query	**Examples**	**Explanation**
VOLT:RMS?	+ 1.0238e+01	Measured voltage 10.238V
POW:ACT?	- 1.8351e+00	Measured power -1.8351W
CURR:RMS?	+ 5.8975e-03	Measured current 5.8975mA
FORM:START 1	+ 9.0000e+00	
FORM:END 5	+ 0.0000e+00	Harmonic currents n = 1 to 5.
CURR:FFT?	+ 3.0000e+00	
	+0.0000e+00	
	+1.8000e+00	

The output data can also be a scaling factor, an instrument setting, a range indication, or an error number.

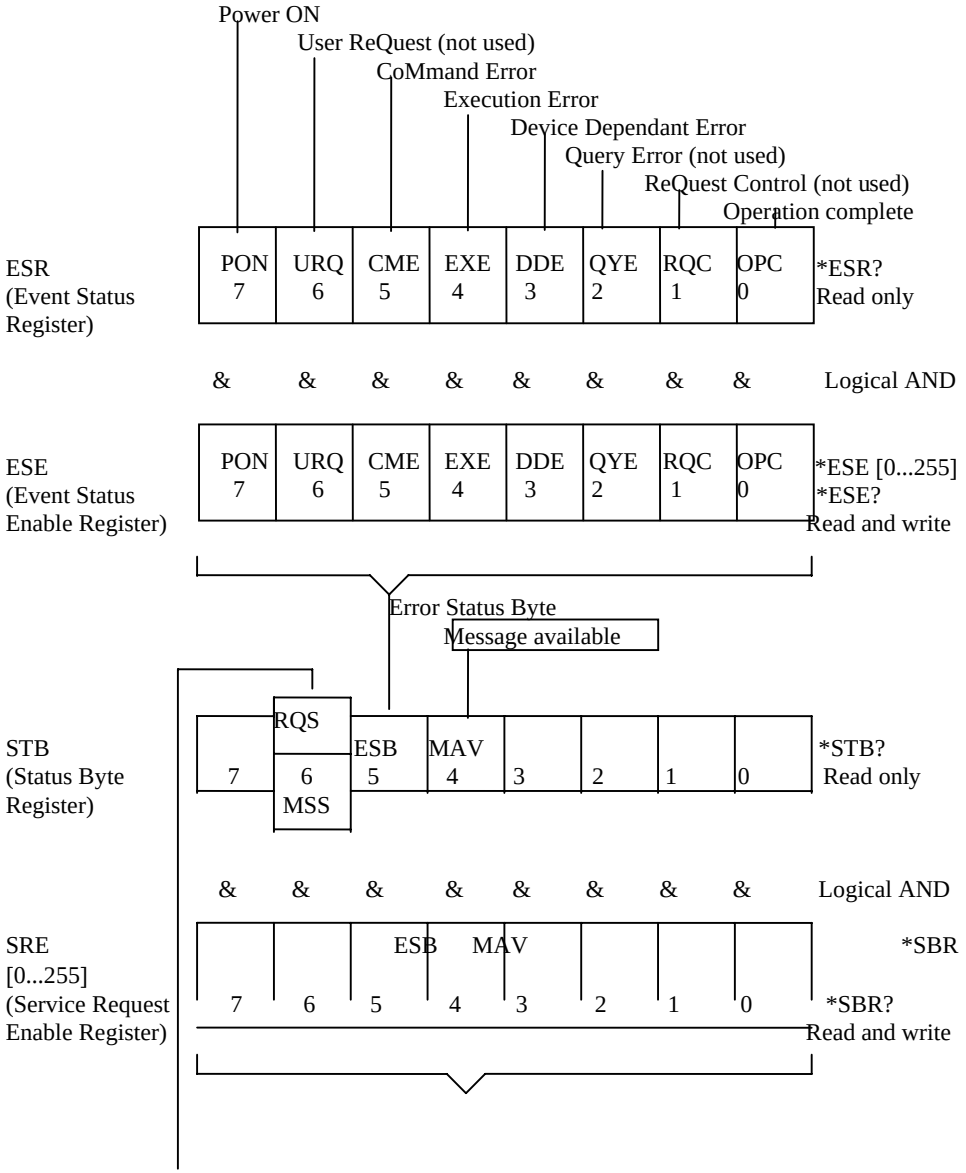
6.6.4. OPTIMIZING SPEED FOR DATA TRANSFER

There may be applications where the speed of data transfer to the host becomes an issue. The speed is increased when you configure the display monitor without graphic area. Avoid communications of unnecessary status commands. For highest speed focus on sending queries for data transfer and reading data from the instrument.

6.7. SERVICE REQUESTS AND STATUS REGISTERS

Service requests let the Spectral Multimeter on the IEEE-488 bus get the attention of the host. Every instrument or the IEEE-bus can set the service request (SRQ) bus line.
The host can determine which instrument made the request by taking a „**serial poll“**. In this process the Status Byte Register will be set to 1, identifying it as an instrument that requested service.
Below the registers are summarized:

Register	**Description**
STB Status Byte Register	Read only. Bit 6 sets SRQ bus line. Read by Serial Poll.
SRE Service Request Enable Register	Read and write. A bit set to 1 in SRE will generate an SRQ when corresponding bit in STB is also 1.
ESR Event Status Register	Read only. Assigns specific events to specific bits.
ESE Event Status Enable Register	Read and wirte. Mask for event generation to set Event Summary Bit.



STATUS AND EVENT REGISTER DEFINITION

EVENT STATUS REGISTER (ESR)
When , for example, a command Error occurs bit 5 is set to 1. The query *ESR? Returns a decimal value corresponding to the bit setting.

EVENT STATUS ENABLE REGISTER (ESE)
It is the mask for the Event Status Register. When for the above example the command Error mask bit 5 is set the command Error would set the Error Status Byte in the Status Byte Register (STB).

STATUS BYTE REGISTER (STB)
The RQS, bit 6, if equal 1 sets the SRQ line true. The status bits 0-5, and 7 determine in conjunction with the mask in the Service Request Enable Register whether RQS is set or not. Reading the Status Byte Register with the query *STB? will return a decimal value, for example „32“. Converting 32 to binary indicates that bit 5 (ESB) is set to 1.

6.8. COMPUTER INTERFACE COMMAND SET

The following table lists the RS-232 and IEEE-488 commands. The RS-232 and IEEE-488 commands are identical, except where indicated. A parameter that must be supplied by the user is enclosed in angle brackets (<parameter>). Commands can be sent in upper case or lower case.

IEEE-488 Interface Function Subsets:
SH1 Source Handshake, AH1 Acceptor Handshake,
T5 Talker, L4 Listener, SR1 Service Request,
RL1 Remote/Local, DC1 Device Clear.

The following conventions are used:

<F> = Field selector; it is an integer 0 to 9 used to select the display field on which a value must be displayed. Field 0 is top left, 1 is top right, ... field 9 is bottom right.

<R> = Scientific formated real number, e.g. +1.0e1.

<N> = Signed integer number, e.g. +1024.

Query commands are terminated with „?“ and do not contain a <parameter>.
That part of the command that is written in capital letters is mandatory. The lower case letters are optional.

COMMAND	**DESCRIPTION**
VOLTage:RMS <F>	Query or set field for DC coupled RMS voltage
:AC <F>	Query or set field for AC coupled RMS voltage
:RECT <F>	Query or set field for rectified mean voltage
:MEAN <F>	Query or set field for arithmetic DC voltage
:MIN <F>	Query or set field for negative peak voltage
:MAX <F>	Query or set field for positive peak voltage
:PEAK <F>	Query or set field for peak to peak voltage
:FFT <F>:G	Set the field (0,1,...,9) for voltage harmonic previously selected by the FORMat:START command. Use the G argument instead of <F> to display FFT(u) in the display graphic zone.
:FFT?	Query all voltage harmonics in the range specified by the FORMat:STart and FORMat:END commands.
:CREST <F>	Query or set field for voltage crest factor
:FORM <F>	Query or set field for voltage form factor
:CURVE	Display u(t) in the display graphic zone
:SCale <R>	Query or set voltage scaling factor
:THD <F>	Query or set field for Total Harmonic Distortion
:PST<F>	Query crest or set field for short time Flicker (10min.)
:PLT<F>	Query crest or set field for long-time Flicker.
CURRent:RMS <F>	Query or set field for DC coupled RMS current
:AC <F>	Query or set field for AC coupled RMS current
:RECT <F>	Query or set field for rectified mean current
:INT <F>	Query or set field for average charge (short time integration).
:ACCu <F>	Query or set field for charge (long-time integration)
:RESET	Reset charge, no query form
:MEAN <F>	Query or set field for DC current
:MIN <F>	Query or set field for negative peak current
:MAX <F>	Query or set field for positive peak current
:PEAK <F>	Query or set field for peak to peak current
:FFT <F>:G	Set the field (0,1,...,9) for current harmonic previously selected by the FORMat:START command. Use the G argument instead of <F> to display the FFT(i) in the display graphic zone.
:FFT?	Query all current harmonics in the range specified by the FORMat:START and FORMat:END commands.
:CREST <F>	Query or set field for current crest factor
:FORM <F>	Query or set field for current form factor
:CURVE	Display i(t) in the display graphic zone.
:SCale <R>	Query or write current scaling factor
:THD <F>	Query or set field for Total Harmonic Distortion

POWer:ACTive <F> Query or set field DC coupled power in Watt

:AC <F> Query or set field AC coupled power in Watt

:INT <F> Query or set field DC coupled average energy (short time integration)

:AC <F> Query or set field AC coupled average energy (short time integration)

:APParent <F> Query or set field DC coupled apparent power

:AC <F> Query or set field AC coupled apparent power

:INT <F> Query or set field DC coupled average apparent energy (short time integration)

:AC <F> Query or set field AC coupled average apparent energy (short time integration)

:REActive <F> Query or set field DC coupled reactive power

:AC <F> Query or set field AC coupled reactive power

:INT <F> Query or set field DC coupled average reactive energy (short time integration)

:AC <F> Query or set field AC coupled average reactive energy (short time integration)

:FFT <F>:G Set the field (0,1,...,9) for the power harmonic previously selected by the FORMat:START and FORMat:END command. Use the G argument instead of <F> to display FFT(p) in the display graphic zone.

:FFT? Query all power harmonics in the range specified by the FORMat:STart and FORMat:END commands.

:**FACtor <F>** Query or set the field for the DC coupled power factor

:AC <F> Query or set the field for the AC coupled power factor

ENergy:ACTive <F> Query or set field of energy (long time integration)

:APParent <F> Query or set field of apparent energy (long time integration)

:REActive <F> Query or set field or reactive energy (long time integration)

:RESET No query form, resets all energy values

FREQuency <F> Query or set field of current or voltage signal frequency. Depends on current or voltage synchronisation.

IMPedance:MAGnitude <F> Set the field for harmonic impedance previously selected by the FORMat:START command.

:MAGnitude? Query all harmonic impedances in the range specified by the FORMat:START and FORMat:END commands.

:ANGle <F> Set the field for harmonic phase angle previously selected by the FORMat:START command.

:ANGle? Query all harmonic phase angles in the range specified by the FORMat:START and FORMat:END commands.

ACQuire:RANge:VOLTage Auto | 600M — Query or set voltage range

2
6
20
60
200
600
2000

Examples:
ACQ:RAN:VOLT AUTO Voltage in autoranging.
ACQ:RAN:VOLT 200 Selects 200V range.

ACQuire:RANge:CURRent Auto | 15M | 50M | 150M | 500M | 1.5 | 5 | 15 | 1 | 3 | 10 | 30 | 100 | 60M | 200M | 600M | 2 | 6 — Query or set current input range (the valid option column is fixed by the active input, IN5, IN30, and SHUNT)

:INput IN5 | IN30 | SHunt — Query or set the current input or the shunt input.

:MEAsuremo CURRent | VOLTage | POWer | BURSTIi | BURSTUu | FLicker — Query or set instrument measure mode.

:APERture 100M | 250M | 500M | 1 | 2 | IEC555-2 — Query or set the minimal averaging time

Example:
ACQ:APER 500m Sets minimal averaging time to 500ms.

:Hold Run | Stop — Query or set acquisition subsystem.
Display data are held.

:QUality? Query overload and underload of current and voltage inputs. An integer is returned. The integer indicates the state during the previous query (VOLT:,CURR:,POW:,EN:, or FREQ:). For more details refer to overload and underload register definition.

DISplay:FORMat [0..5] Query or set the number of numeric fields on the panel.
:PRint Print displayed values.

FORMat:START <N>
:END <N>
Query or set the range for data array transfer
Range of N for harmonic values is 1 to 63
Range of N for analog inputs is 0-7.
If the value specified is out of range or start>end the correction is done when values are queried using VOLT:FFT?, CURR:FFT?, POW:FFT?, IMP:FFT?, IMP:MAG, IMP:ANG, or AINP?.

AINPort <F> Set display field for analog input port previously selected by the FORMat:START/END command.

AINPort? Query all analog input port values identified by the FORMat:START/END command. Range of allowed ports is 0 to 7.

VERsion? Query form only. Returns software version

LOCk Locks the instrument's front panel controls. The query form returns YES or NO whether the controls are locked or not.

UNLock Unlock the instrument front panel controls.

RS232? Query form only, returns all settings. Output format is BAUD;PARITY;TERM;HAND

RS232:BAUD { 2400 | 4800 | 9600 | 19200 | 38400 | 57600 | 115k2 } Query or set baud rate

:PARITY { None | Even | Odd } Query or set parity mode

:**TERMinator** { CR | LF | CRLf } Query or set command terminating characters.

:HANDshakes { None | Xon } Query or set handshake mode

GPIB:ADDRess [0..30] Query or set GPIB address

***ESE [0..255]** Query or set the Event Status Enable register

***SRE [0...255]** Query or set the Service Request Enable register

***STB?** Query the STatus Byte register (IEEE-488 only)

***ESR?** Query the Event Status Register (IEEE-488 only)

***RST** Resets instrument

***OPC** Set ISR bit 0 if no printing AND no measurement are pending (GPIB only).

***OPC?** Returns 1 if no printing AND no measurement are pending.

***TST?** Performs self test, returns zero if successful

***WAI** Suspends command execution until previous commands are complete.

***TRG** Forces a running measurement to become pending if in RUN mode. Forces a measurement if in STOP mode.

***IDN?** Returns identification string in form:<Vendor, Model, Serial No, Firmware version>.

***CLS** CLear status (no query form), (IEEE-488 only)

ERRor? Query the last error code

ERROR CODES DEFINITIONS:

102 Syntax Error
The command was not recognized. ESR bit 5 is set (CoMmand Error)

110 Command header error
A command followed by '?' was sent were no query form is available. And conversly: no '?' followed a query form only command. ESR bit 5 is set (CoMmand Error).

111 Header separator error
Attempted to descend the command hierarchy at a place where there wasn't any subcommand. ESR bit 5 is set (CoMmand Error).

140 Character data error
A too long and/or sensless command has been sent to the instrument. ESR bit 5 is set (CoMmand Error).

222 Data Out Of Range
The command argument is not allowed. ESR bit 4 is set (EXecution Error).

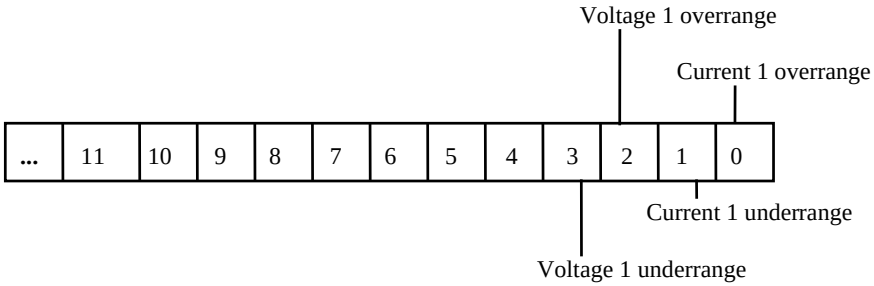
2204 Measurement error, Measurement underflow. ESR bit 4 is set (EXec. Err.).

2207 Measurement error, Measurement overflow. ESR bit 4 is set (EXec. Err.)

350 Queue overflow
This occurs if a query command attempts to place a new message onto the instruments output queue but there was still an old message waiting on the queue. This results in information loss. The query answer is replaced by '350' and ESR bit 3 is set (Device Dependant Error).

2200 Input signal over- and underload. One or more current- or voltage inputs were in over- or underload during the last query (VOLT:,CURR:,POW:,EN:, FREQ:).
ESR bit 4 is set.

Overload and Underload Register Definition



Bit 15 ... 5 are not defined and are reserved for extension.

7. THE SPECTRAL MULTIMETER OPTIONS

The Spectral Multimeter can be equipped with options 01, 02, and 03 which are all mounted on the Option Assembly Board. Option 04 is external to the Spectral Multimeter.

7.1. INSTALLING THE OPTION ASSEMBLY

WARNING: To avoid electric shock, disconnect the power cord and test leads before removing the instrument hood.

Remove three screws each on the left and right hand side of the hood and slide it over the top of the instrument.
Figure 7.1. shows the physical location of the Option Assembly. Figure 7.2. shows the flat ribbon connecting cables from the Option Assembly to the Processor Assembly and from the Option Assembly to the rear panel.
To install the Option Assembly remove first the front panel. Along the left and right front edge there are 4 and along the bottom edge there are 2 screws. Unscrew them and slide out the front panel, disconnect J21 (display connector) and put the front panel face down between the two instrument side panels.
In this position you can install the Option Assembly by first connecting J42 to the DC/DC Converter Assembly, J34 to J16, J35 to J15. Now fasten the Option Assembly onto the three bolts on the Processor Assembly.
Connect the option output cables J37 (printer output), J38 (RS-232 output), J36 (IEEE-488), J39 (Analog-in and analog output). All these cables go from the Option Assembly, over the Separator (Figure 7.1.), along the right hand side panel to the rear panel.
The clips supplied are used to hold the cables above the main supply. Keep the cables 1cm away from any part of the main supply. Fold the 24pol flat ribbon cable around the 14pol cables and insert this package in the clips. Stick the clips to the side panel such that the edges of the flat ribbon cables are along the side panel top edge. (see Figure 7.3).
Finally, mount the aluminum cable separator between power supply and flat ribbon cables. Loosen the two top screws of the power supply binding posts and place cable separator between side panel and binding posts, fasten the two screws again.

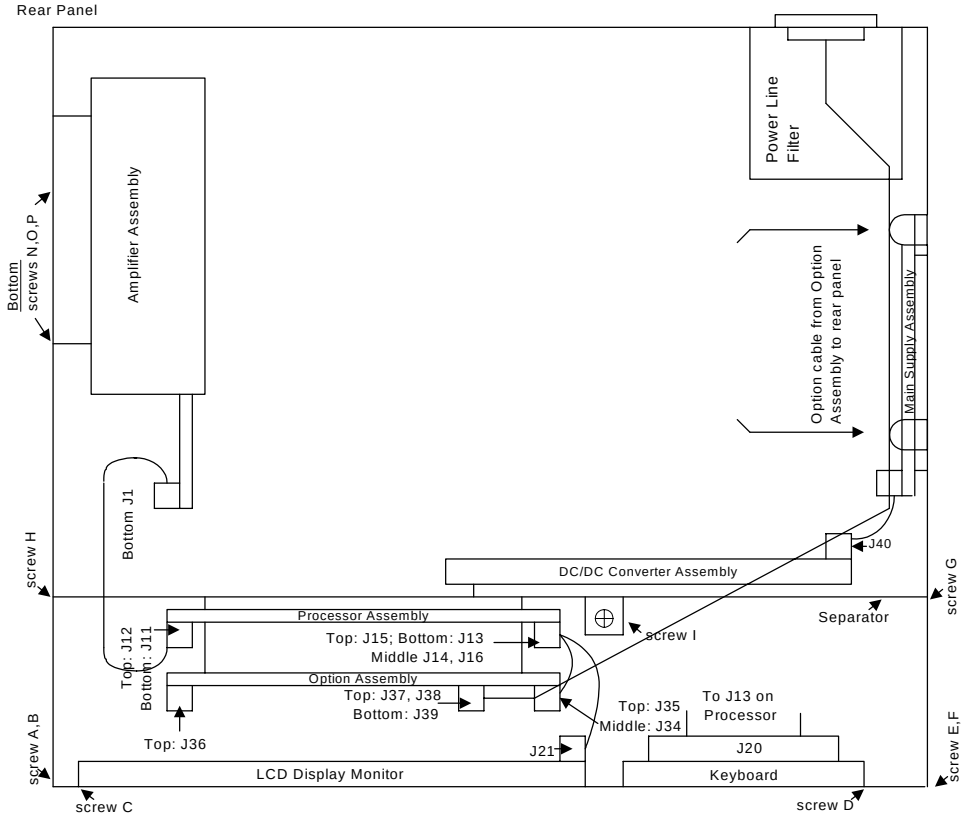


Figure 7.1. Physical location of Option Assembly Unit

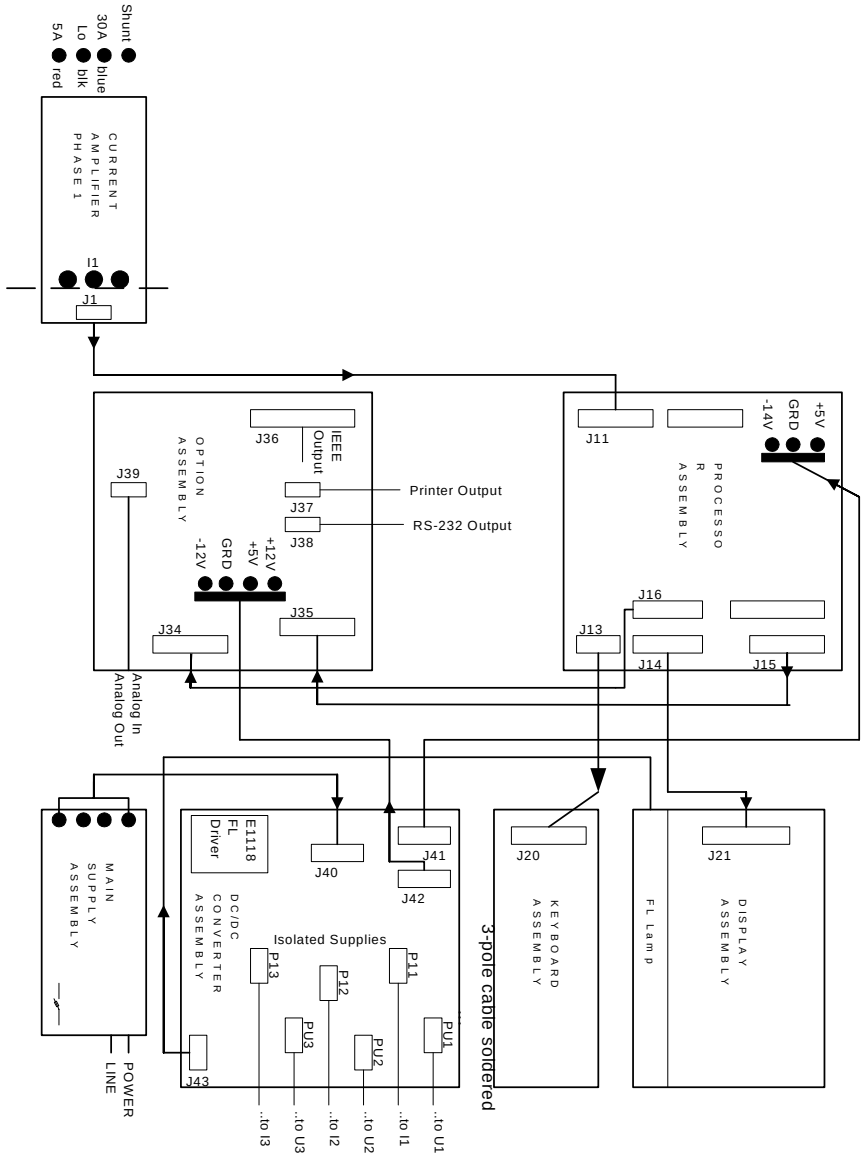


Figure 7.2. Connection of Option Assembly Unit

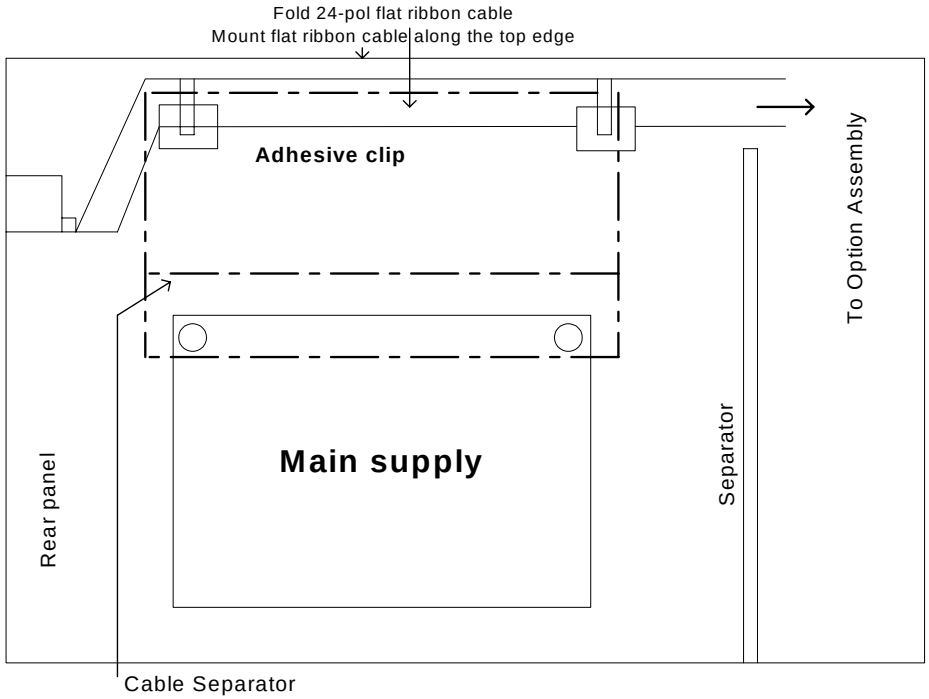
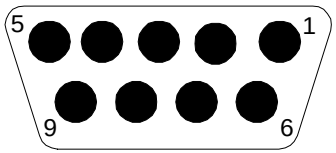


Figure 7.3. Fixation of Option Cables

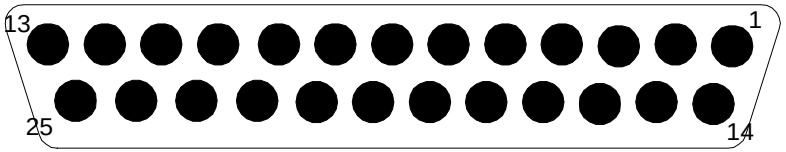
7.2. OUTPUT CONNECTORS

a) RS-232 Connector



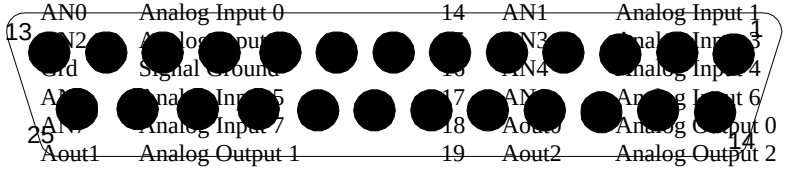
1	DCD	Data Carrier Detect
2	RxD	Received Data
3	TxD	Transmitted Data
4	DTR	Data Terminal Ready
5	Grd	Signal Ground
6	DSR	Data Set Ready
7	RTS	Request To Send
8	CTS	Clear To Send
9	RNG	Ring

b) Printer Output Connector



1	Strobe	8	Acknowledge
2	Data Bit 0	9	Busy
3	Data Bit 1	10	Paper Empty
4	Data Bit 2	11	Select
5	Data Bit 3	12	NC
6	Data Bit 4	13	Error
7	Data Bit 5	14	NC
8	Data Bit 6	15	NC
9	Data Bit 7	18-25	Ground

c) Analog-in and Analog Output Connector



1	AN0	Analog Input 0	14	AN1	Analog Input 1
2	AN2	Analog Input 2	15	AN3	Analog Input 3
3	Grd	Signal Ground	16	AN4	Analog Input 4
4	AN5	Analog Input 5	17	AN6	Analog Input 6
5	AN7	Analog Input 7	18	Aout0	Analog Output 0
6	Aout1	Analog Output 1	19	Aout2	Analog Output 2
7	Aout3	Analog Output 3	20	Grd	Signal Ground
8	AUX1	Auxiliary IN/OUT1	21	AUX2	Auxiliary IN/OUT 2
9	AUX3	Auxiliary IN/OUT 3	22	AUX4	Auxiliary IN/OUT4
10	+12V DC (Option 04)		23	NC	
11	+12V DC (Option 04)		24	-12V DC (Option 04)	
12	Supply Ground (Option 04)		25	-12V DC (Option 04)	

7.3. ANALOG INPUTS

Eight analog inputs are provided to be connected to external transducers such as torque -, speed -, acceleration -, frequency -, and temperature transducers. The four inputs AN0, AN1, AN2, and AN3 are for the input range 0 to ±10V. They exhibit a 200kΩ input impedance and have a typical accuracy of ±0.2 % full scale. The full scale display is ±10.000V.

The other four inputs AN4, AN5, AN6, and AN7 are for the input range 0 to ±5V. They all have an input impedance of 100kΩ and also a typical accuracy of ±0.2 % full scale. The full scale display is ±5.0000V. Note that all inputs are referenced to ground at the rear panel analog in- out connector and are not galvanically isolated from each other nor galvanically isolated from the Spectral Multimeter main electronics. All eight analog inputs are sampled before every display update and are stored to either be displayed on the display monitor or to be read over the interface.

Any one of the eight analog inputs can be displayed in any display number field. To display for example, AN3 in display number field 0 (top left), move the cursor to this field and press **SET**. From the selection table you select Aninp and press **SET** to come back to the display number field. Now the menu at the bottom of the display allows you to step through A00 to A07 (displayed in the side menu). Select A03 to display analog input 03 at the desired display position.

The analog inputs can be read via interface. The following sequence of commands would transfer all eight analog input values to the host.

```
FORMAT:START 0
FORMAT:END 7
AINPort?
```

The following sequence of commands would display analog input 03 in display number field 0.

```
FORMAT:START 3
FORMAT.END 3
AINPort 0
```

7.4. FOUR ANALOG OUTPUTS

The four analog outputs Aout0, Aout1, Aout2, and Aout3 are ±5V outputs proportional to the 4 quantities displayed in the display number fields 0, 1, 2, and 3. Any one of the quantities listed in the table below can be output.

Voltage current	rms	rectified	mean	max	min	ptp	FFT
Power	Pactiv	FFT	PF				

If any other quantity not defined in above table is output over the analog output its value is either zero or is not defined. The analog outputs are updated synchronously with the display. This means, that the updating depends on the selected measurement time. The output accuracy is ±0.1 % of the displayed value. The output impedance is 100Ω.
The analog output is 5V for full scale display. For practical purposes we call the voltage ranges 0.6V, 2V, 6V, 20V, ... Because the internal range setting is a 1, √10, 10, 10√10, 100, ... sequence, the actual voltage ranges are: 0.2√10V, 2V, 2√10V, 20V, 20√10V, etc. As a consequence in the 2V range the analog output will be 5V for 2.0000V display and in the 6V range the output will be 5V for a display of 6.3244V.
The table below lists the actual voltage-, current-, and shunt ranges for full scale analog output. For power the products of voltage-times current range determine the display for 5V analog output.
The only exception is the power factor. PF=+1 corresponds to +5V and PF-1 corresponds to -5V analog output.

Ranges and their full scale display for 5V analog output	
Voltage:	0.2√10V, 2V, 2√10V, 20V, 20√10V, 200V, 200√10V, 2000V
Current:	5√10mA, 50mA, 50√10mA, 500mA, 500√10mA, 5A 1A, 1√10A, 10A, 10√10A
Shunt:	60mV, 60√10mV, 600mV, 600√10, 6V
Power:	any product of above voltage ranges times current ranges (or shunt voltage).
Power Factor:	PF=±1 corresponds to ±5V analog output.

The Spectral Multimeter outputs the quantities displayed in the display number fields 0 (Aout 0), 1 (Aout 1), 2(Aout 2), and 3 (Aout 3) as long as they are a set of the above table.

7.5. CURRENT SENSOR MODULES

The current sensor modules provide current measurement capabilities from DC to 10kHz. The modules are directly supplied from the Spectral Multimeter by connecting the 25 pol D-Sub connector to the rear panel analog-In-out connector.
The current sensor outputs are connected to the 0-5A Spectral Multimeter input. Scaling the current yields actual current readings. All other quantities are scaled accordingly.

Specifications:

Current range:	25A-1000A	Accuracy:	±0.5 %, 2Hz-200Hz; 1 %, 200Hz-1kHz
Frequency range:	DC-10kHz	Scaling:	required

WARNING: Before applying the primary current to the Hall sensors make sure the supply from the Analog-in-out connector is installed and the Spectral Multimeter is turned on. Also make sure the Hall sensor outputs are properly connected.
An open connection could cause damage to the Hall Sensors.

7.6. PRINTER OUTPUT

The Centronics printer output prints measurement data shown in the display number fields. In the Spectral Multimeter start-up configuration 6 values are displayed. To print these values move the cursor to the side menu and select the „PRINT“ menu. One value per line is printed. Every line is terminated by CR/LF.

7.7. EXTERNAL SYNCHRONISATION

This option provides means to synchronize the Spectral Multimeter measurements to external TTL-signals. You must deactivate the I/U-synchronization by connecting pin 8 and 9 on the analog-in / analog-out connector. The Hi-input of the TTL-signal is at pin 21 and the Lo-input at pin 8/9. The frequency range is 5Hz to 50kHz. The displayed frequency is that of the synchronization signal.

7.8. DISTURBANCE PREVENTION

When you are connecting any option to an external device you provide additional paths for common mode transients to flow from the Spectral Multimeter inputs across the isolation barrier through the installed option to the external device. Such disturbances may cause malfunctions particularly of the RS-232 interface.
Pulling the external cable through a ferrite torroid such as Siemens B64290-K674-X830 forming several windings will reduce the flow of the transients >10 windings yield good results. A similar filter can be added at the SM201 input.

8. CALIBRATION PROCEDURE

8.1. CALIBRATION CYCLE

We recommend to verify calibration once a year. The user must be aware that occasional overloads (voltage and current) will degrade accuracy. In such cases, calibration should be checked more frequently.

8.2. EQUIPMENT NEEDED

A calibrator that will supply voltages 0.3V-600V and currents 15mA-2A at 60Hz with 0.02 % accuracy will suffice.

8.3. PREPARING FOR CALIBRATION

Remove the hood of the Spectral Multimeter by loosening 3 screws on the left and the right hand side. Slide the hood over the top of the instrument.
Turn Spectral Multimeter on and allow approximately 30 minutes warm-up time.

8.4. OFFSET ADJUSTMENT AND CALIBRATION

Figure 8.1. shows the locations that have to be adjusted.
Make sure all scaling factors are set to 1.0000.

NOTE: The shield of the amplifier is on the potential of the corresponding Lo-terminal input.

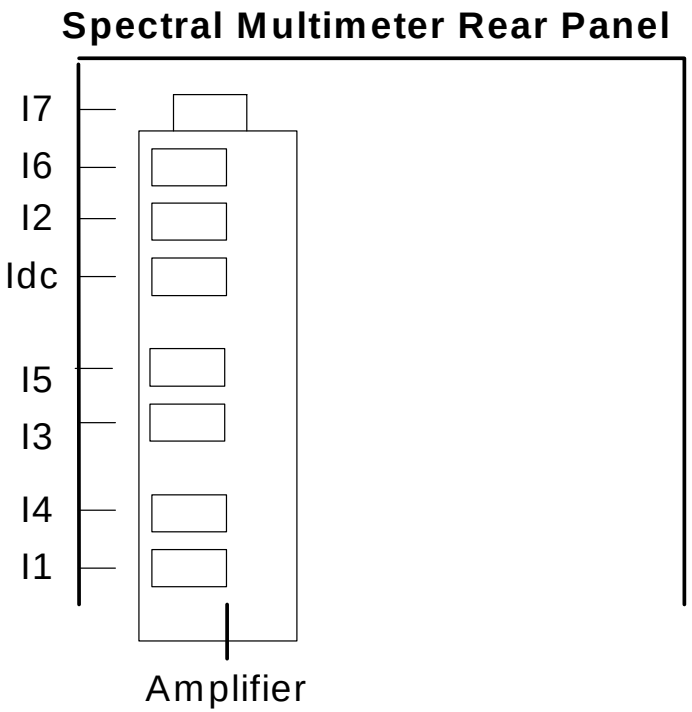


Figure 8.1. Location of Calibration Adjustments

8.4.1. AMPLIFIER OFFSET ADJUSTMENT

Select Mode I, select display of current mean value. Leave the current inputs open. Select 5A input and 15mA current range.
Adjust Idc to obtain a minimal reading for the current mean value. The reading is typically ±20uA.

8.4.2. CURRENT CALIBRATION

Apply a 60Hz current to the 5A input „IN5A“ or the 30A input „IN30A“.Make sure you have selected the correct current input on the Spectral Multimeter front panel.

Calibrator Output	Input	Range	Adjustment, rms current
2A (3A) 50mA		IN30A	3A adjust I1 for 2.0000A (3.0000A) IN5A 50mA adjust I2 for 50.000mA
Repeat above steps at least once before proceeding to the steps below.			
15mA 150mA 1.5A		IN5A	IN5A 15mA adjust I3 for 15.000mA 150mA adjust for 150.00mA IN5A 1.5A adjust I5 for 1.5000A

8.4.3. VOLTAGE CALIBRATION

Select Mode U. Select 20V range and apply 20V/60Hz. Adjust I6 for 20.000 Vrms display.

8.4.4. SHUNT INPUT CALIBRATION

Select Mode I. Select 600mV shunt range. Apply 600mV/60Hz and adjust I7 for 10.000 Arms display.

8.4.5. POWER / FLICKER / BURST / CALIBRATION

Power is the precise product of current and voltage and is also calibrated with above steps. Flicker and Burst is also calibrated with above steps.

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KONFORMITÄTSERKLÄRUNG
DECLARATION OF CONFORMITY
DÉCLARATION DE CONFORMITÉ

Wir
We **Infratek AG**
Nous

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(Name des Anbieters) (supplier's name) (nom du fournisseur)

Weingartenstrasse 6, CH-8707 Uetikon am See

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(Anschrift) (address) (adresse)

erklären in alleiniger Verantwortung, dass das Produkt
declare under our sole responsibility that the product
déclarons sous notre seule responsabilité que le produit

SM201 SPECTRAL MULTIMETER

_____

_____
(Bezeichnung Typ oder Modell, Los-, Chargen- oder Seriennummer, möglichst Herkunft und Stückzahl)
(name, type or model, lot, batch or serial number, possibly sources and numbers of items)
(nom, type ou modèle, no de lot, d'échantillon ou de série, éventuellement sources et nombre d'éxemplaires)

auf das sich diese Erklärung bezieht, mit der/den folgenden Norm(en) oder nomativen Dokument(en) übereinstimmt.
to which this declaration relates is in conformity with the following standard(s) or other normative document(s)
auquel se réfère cette déclaration est conforme à la (aux) norme(s) ou autre(s) document(s) normatif(s)

EN 50081-1; EN 50082-2; CEI/IEC 1010-1, Amendment 1/2;

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(title and/or number and date of issue of the standard(s) or other normative document(s))
(titre et/ou no et date de publication de la (des) norme(s) ou autre(s) document(s) normatif(s))

Gemäss den Bestimmungen der Richtlinie(n); following the provisions of Directive(s); conformément aux dispositions de(s) Directive(s)
(falls zutreffend) (if applicable) (le cas échéant)

89/336/EWG

_____

Uetikon am See, 1.11.2000 Dr. Hans R. Oppliger

_____
(Ort und Datum der Ausstellung) (Name und Unterschrift oder gleichwertige Kennzeichnung des Befugten)
(Place and date of issue) (name and signature or equivalent marking of authorized person)
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