MEASAR SOLO: A Measuring Instrument for Single CEMs

Description

MEASAR SOLO is a complete measuring instrument to operate single channel electron multipliers (CEMs) or photomultipliers (PMTs) and evaluate the output signal by pulse counting as well as current and integral charge measuring.
Functionality is the same as that of MEASAR SYSTEM for CEM-Arrays. Operation is performed exclusively via the RS232 interface, the only direct mechanical control is a safety switch to turn off the high voltage. In contrast to MEASAR SYSTEM a bridging circuit USB-to-RS232 is built-in, which creates a virtual COM-interface via USB hardware. Selection which interface to be used is performed with a slide switch in the backpanel.
Three different models are available:

- MEASAR SOLO-N with negative high voltage
- MEASAR SOLO-P with positive high voltage
- MEASAR SOLO-D with positive and negative high voltage, to be selected by slide switch

For interface details and protocol see document *MEASAR SOLO Interface Protocol_rev B.pdf* .
Software to operate MEASAR is available, it is identical for MEASAR SYSTEM and MEASAR SOLO.

Fig. 1: Front view of MEASAR SOLO.

Case: Aluminum, width × height × depth = 205 × 55 × 225 mm³

Werksstrasse 15
D-45527 Hattingen phone: +49 2324 506764 fax: +49 2324 506765 email: wmt.elektronik@t-online.de

CEMs are operated in ultra-high-vacuum, HV-throughputs (BNC-HT, SHV, or equivalent, MEASAR SOLO is equipped with BNC-HT), are necessary for High Voltage and -with positive HV- for ANODE BIAS. For SIGNAL a BNC throughput is sufficient.
The signal cables must be coaxial 50 Ω type, e.g. RG 58/U or -preferably because of its double shield- RG 223/U.

2. Programmable Measurement Parameters

High Voltage:

HV(11:0)	12 bit binary for high voltage: +128 V to +4095 V (SOLO-P) - 128 V to - 4095 V (SOLO-N) step size = 1 V, max. output power = 1.0 W Voltages with absolute value < 128 V are internally set to zero.
HV-slope	1 bit for high voltage slope = ± 100 V/s or ± 800 V/s

Pulse Detection:

THR(7:0)	8 bit binary for discriminator threshold = 3 mV to 130.5 mV input referred, step size = 0.5 mV. For a typical pulse width of 7 ns (FWHM) this is equivalent to CEM output charge 0.42 to 18.3 pC.
DTIM(1:0)	2 bit binary for dead time = 15 - 30 - 60 - 100 ns

Measurement Time Interval:

MEAST(15:0)	16 bit binary to determine the measurement time interval: MEAST(15:0) = 0000_{hex} : unlimited, stop by command MEAST(15:0) = 0001_{hex} to $FFFF_{hex}$ for intervals 10 ms to 655.35 s with auto-stop
AUTO(7:0)	8 bit binary for single or automatically repeated measurement: $00_{hex} \Rightarrow$ unlimited number of measurements to be ended by command, $01_{hex} \div FF_{hex} \Rightarrow 1 \div 255$ measurements. In AUTO mode uninterrupted counting is provided and the counter data are transferred periodically without read command to the host computer, if parameter F is asserted.

CEM Overload Protection:

COP (3:0)	4 bit binary determine: in SOLO-N: the maximum allowable anode current, averaged over one second. Step size is 1.024 µA. in SOLO-P: the maximum allowable rate. Step size 204,800 counts/sec COP(3:0) = 0000 disables this overload protection.

Counter Readout:

F	Parameter F determines, whether the counter result is read out automatically after the measurement ends (F = 1), or not (F = 0).

3. Commands

SET HV	Determines high voltage value and slope.
READ HV	Reads the actual high voltage and slope.
SET THRSH	Determines the discriminator threshold and dead time.
READ THRSH	Reads the discriminator threshold and dead time.
SET MEASTIM	Determines duration of measurement interval.
READ MEASTIM	Reads duration of measurement interval.
SET AUTO	Determines number of automatically repeated measurements.
READ AUTO	Reads number of automatically repeated measurements.
SET COP	Determines CEM overload threshold.
READ COP	Reads CEM overload threshold.
SET F	Determines auto-read mode.
READ F	Reads read-mode.
START	Enables counter, starts measurement.
STOPIM	Ends measurement immediately.
STOP	Ends measurement after the end of the present measurement interval.
READ I	Reads actual anode current of CEM, 16 bit binary.
READ Q	Reads integral charge of last measurement interval, 16 bit binary.
READ CNT	Reads the counter result, 32 bit binary.

NOTE: The ADC to measure the current, the integrator to calculate the the integral charge, and the counter all have saturation characteristics, i. e. they do not overflow. Readings of I, Q, or CNT with all "1s" shall be rated as overflow.

For a detailed listing of the software protocol refer to *MEASAR SOLO_RS232 Interface_revB.pdf* .

4. Front Panel Elements

LED "CONNECTED" :	green:	controller is connected to host computer
	red:	no connection
	off:	controller is not powered
LED "MEAS ON" :	red:	a measurement is running
	off:	system is idle or not powered
LED "HV STATUS":	red:	HV is OFF
	orange:	HV is ramping up or down to the programmed value
	green:	HV has the programmed value.

HV RESET:	flip switch with two settling positions and one touch contact:	
	bottom position:	HV OFF, overrides host setting of HV
	middle position:	HV ON. After switchoff, the high voltage is not yet on, but can be activated by host command.
	top touch contact:	HV is reset to the previous set value
SIGNAL IN:	BNC connector for the signal input, DC-coupled. For positive HV the coupling capacitor must be located inside the vacuum chamber or directly at the throughput, the cable must not carry HV to avoid false counts due to leakage current. The capacitance value depends on the pulse risetime and width; for CEMs 220 pF to 470 pF is suited.	
HV OUT:	BNC-HT connector, high voltage output.	
	SOLO-P:	connect to CEM anode via 1 MOhm resistor.
	SOLO-N:	connect to CEM cathode.
ANODE BIAS:	SOLO-P, SOLO-N:	BNC-HT connector, voltage is HV - 120 V, connect to positive side of channel.
	SOLO-N:	BNC connector, voltage is - 120 V, connect to positive side of channel.

5. Back Panel Elements

Sub-D9:	RS232 connector, null-modem cable is required
USB:	To be connected to the host via USB cable. Software to implement a virtual COM connection is delivered with MEASAR SOLO.
Slide Switch RS232 - USB:	Determines the active connection
Slide Switch P - N:	Determines HV polarity (SOLO-D only)

6. High voltage generator:

Output Voltage:	128 V to 4095 V, programmable in 1 V steps. High voltage is positive in SOLO-P, negative in SOLO-N, polarity selectable in SOLO-D. **Polarity must not be changed when HV is ON.**
Max Output Power:	1.0 W, overload and short-circuit protected
Anode Bias Output:	SOLO-P: +HV - 120 V SOLO-N: - 120 V
Slew Rate:	± 100 V/s or ± 800 V/s, programmable An emergency switch for immediate turn-off is provided on the front panel. HV-reset is manually by pressing a frontpanel button or by reprogramming the HV value.

7. Preamplifier/Discriminator

Input Impedance:	50 Ω dc-coupled
Threshold:	Programmable: 3 mV to 130.5 mV input referred. For a typical pulse width of 7 ns (FWHM) this is equivalent to 0.42 to 18.3 pC CEM output charge. Note: With CEM gain = 10^8 a single electron at the CEM input produces 16 pC output charge in the average.
Dead Time:	Programmable: 15 - 30 - 60 - 100 ns.

8. Transimpedance Amplifier

A transimpedance amplifier with 16-bit-ADC is included in SOLO-N and SOLO-D. In SOLO-D current measurement is possible only with negative high voltage, because the CEM is ac-coupled. Full scale is 16.38375 µA, the quantization step is 250 pA, bandwidth is 1 kHz (- 3 dB), the ADC`s conversion rate is 51.2 kHz. The momentary current can be read by the computer at any time.
A programmable overload threshold for the anode current is set by the computer. Exceeding the threshold turns off the high voltage to protect the CEMs. In addition a fixed hardware threshold is implemented in SOLO_N, the high voltage is turned off, if the anode current exceeds 25 µA. Furthermore the current is digitally integrated over the measurement time interval and the accumulated charge can be read after the measurement is completed. Resolution for the charge is 16 bit, quantisation step size is 5.12 nC, full scale is 335.5392 µC.

9. Specifications

9.1. General

Ambient Temperature:	Operating:	0 °C ÷ +50 °C
	Storage:	-20 °C ÷ +80 °C
Humidity (non condensing):	80 % max.	
Electromagnetic Compatibility (EMC):	Emissions EN 55022, level B	

9.2. Measurement Accuracy

Measurement time interval:	$\pm 10^{-4}$
High Voltage:	setting: $\pm 10^{-3} \pm 3$ V for 200 V ≤ HV ≤ 3800 V
	reading: $\pm 10^{-3} \pm 2$ V for 200 V ≤ HV ≤ 3800 V
Anode Bias:	HV - (120 ± 10)V for positive HV, - (120 ± 10)V for negative HV
Discriminator Threshold:	± 2 % ± 0.3 mV
Dead Time:	± 5 % ± 1 ns
Current and Charge:	± 1 %

A final test protocol with measured values is delivered with each module.

9.3. Power Supply

Power is supplied by external + 5 V mains plug unit, delivered with MEASAR SOLO. Max current consumption is < 0.8 A.

10. Measurement Setup for Negative or Positive High Voltage

Connection scheme for negative high voltage:

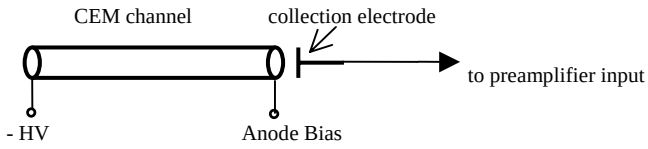

Fig. 2: CEM with negative high voltage

The collection electrode is grounded in MEASAR SOLO through the 50 Ω input resistance, the CEM channel voltage is:

$$V_{channel} = - HV - ANODE\ BIAS = - (HV - 120\ V)$$

For positive high voltage supply the collection electrode must be biased to high voltage with a resistor, typically 1 MΩ, and connected to the signal input of MEASAR SOLO via a high voltage capacitor, typically 220 pF to 470 pF.
The resistor and coupling capacitor are best placed within the vacuum chamber directly at the CEMs. If this is not possible, they have to be placed directly at the throughputs. The signal cable (coaxial 50 Ω type) must not carry high voltage, because the dielectricum is not a perfect insulator. Free charge carriers are moved by high voltage, and these current pulses are detected in the counter and will be interpreted as dark current pulses, although not created in the CEM.

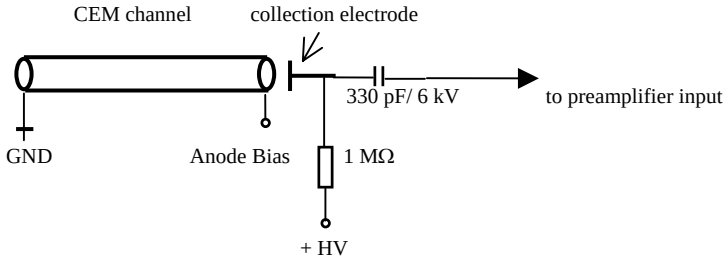

Fig. 3: CEM-array with positive high voltage

The CEM channel is grounded at the input and biased to ANODE BIAS, the collection electrode is biased to HV. The CEM channel voltage is:

$$V_{channel} = ANODE\ BIAS = HV - 120\ V$$