

SPECTECH

Spectrum Techniques

**Model ST250
Ratemeter**

**Instruction
Manual**

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Model **ST250** **RATEMETER**

The ST250 brings new concepts to the popular ratemeter for basic nuclear radiation measurements. The low power design combined with internal rechargeable batteries allows up to 8-hours of portable operation, or continuous benchtop use with the AC-line power/charger supplied. Its rugged design and advanced circuitry is capable of counting more than 150,000 events per minute making full utilization of modern Geiger counters. The variable fully regulated high voltage supply will support many different types of GM tubes with operating plateaus up to 1200v.

In keeping with today's World Class instruments, the ST250 Ratemeter features a large, easy to read meter with dual scales for direct reading in both counts per minute and in counts per second for international markets. To aid in classroom demonstrations of basic radiation properties, a data link and software program provides direct connection to IBM-PC compatibles for computer screen display of digital and simulated analog information. Experiments may be run directly from the computer and data is stored in files which may be transferred directly to many common spreadsheet programs. This advanced feature provides access to the powerful spreadsheet functions such as mathematical calculations, charting, and graphical output of data when performing radiation measurements, nuclear science, and health physics experiments.

Light weight combined with battery power, audio output, variable high voltage, and computer Data Link makes the *SPECTECH ST250 Ratemeter* an extremely flexible instrument for radiation surveying, nuclear science instruction and health physics training.

Specifications.

Input:
counters.

High voltage:
turn potentiometer.

Display:

Ranges:
150000.

2500.

Audio:

Data Link:
to computer

Power:
LOW POWER indicator.
full charge. Input 7.5 volt DC, at
line charger.

time of order

Dimensions:

Software Supplied:
DOS program runs on

EGA, VGA, SVGA, and

ratemeter, auto ranging, CPM
ratemeter, nuclear scaler, preset timer,

BNC connector. Accepts standard Geiger

0 to +1200volts, continuously variable by 10-

precision 4.5" meter.

CPM--- 600, 1500, 6000, 1500, 60000,

CPS--- 10, 25, 100, 250, 1000,

HIGH VOLTAGE---0 to 1200 volts.

Piezo alerter with full volume control.

DB-9 male, accepts standard cable to connect
serial port.

internal rechargeable NiCd batteries, with
Typically 8-hours run time on
300mA from AC

Specify 110-120, or 220-240 VAC charger at

12 in.W,x 8 in.H,x 4.5 in.D

ST250 Ratemeter-PC emulation software.

most IBM compatible PC's including CGA,

and Hercules graphics systems.

Real time display of simulated analog

or CPS, digital

spreadsheet compatible data files.

OPERATION

CAUTION

Never operate the ST250 Ratemeter with the GM probe disconnected. Dangerous voltages can exist at the probe connector so ensure the instrument is in the OFF position and the high voltage is set to zero before disconnecting or reconnecting the GM probe.

General

The ST250 Ratemeter contains internal nickel/cadmium rechargeable batteries. Before operating the instrument it may be necessary to connect the charger to provide power to run the unit and recharge the batteries. When fully charged, the batteries can supply power for up to 8 hours of use. Overnight charging is recommended, coupled with periodic discharging to maintain good battery life and condition.

A LOW BATTERY indicator is included to alert the operator before the batteries become fully exhausted and the instrument ceases to function. If this indicator is illuminated, discontinue use until the unit has been reconnected to the charger.

Detectors

Geiger-Mueller tubes produce electrical pulses when ionizing radiation events occur within their sensitive volume. For proper operation, these detectors should be run at a predetermined operating voltage specified by the manufacturer or derived empirically. To improve sensitivity to alpha and beta particle radiation, many GM tubes have extremely thin entrance windows which require considerable care in handling. Do not remove protective caps unless necessary and never touch the window.

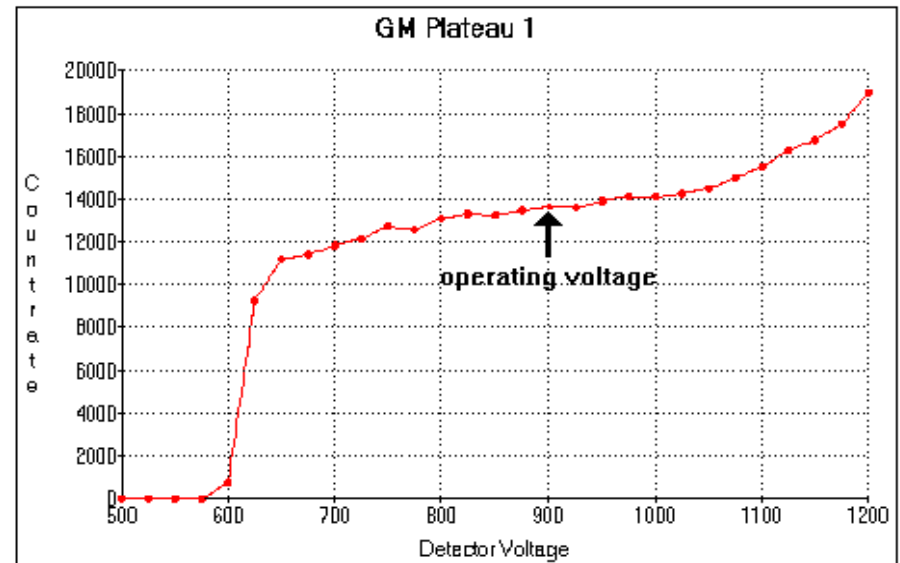
The ST250 is designed to accommodate many types of GM probes and includes a fully adjustable high voltage power supply to cover a wide range of applications. The high voltage level may be displayed on the meter by moving the FUNCTION switch to the HV position, and reading the voltage on the lower scale. Adjustments to the high voltage may now be made using the HV ADJ. control.

GM Plateau

The correct operating voltage for the Geiger-Mueller tube may be determined experimentally using a small radioactive source such as Cs-137 or Co-60. A properly functioning tube will exhibit a "plateau" effect, where the counting rate remains nearly constant over a range of applied voltage. Place the radioactive source close to the window of the GM probe and slowly increase the high voltage until radiation events just begin to be detected. Now increase the voltage in 50 volt steps recording the counting rate at each increment. The rate should remain fairly constant over a range of voltage and then increase rapidly as the high voltage is further raised indicating that the tube is entering the breakdown region. Do not continue to operate the tube in this breakdown condition but reduce the high voltage and make a plot of the counting rate versus the applied voltage. The recommended operating voltage may now be determined as the center of the plateau region.

Operation

For basic operation it is only necessary to connect the GM probe and set the high voltage to the correct operating level. Select the **H.V.** position on the function switch and read the high voltage value directly from the meter. The instrument is now ready for use and the function switch should be returned to the **COUNT** position and the appropriate range selected. An overrange condition will not damage the meter as a limiter is incorporated into the design.



Resolving Time

Geiger-Mueller tube exhibit dead time effects due to the recombination time of the internal gas ions after the occurrence of an ionizing event. The actual dead time depends on several factors including the active volume and shape of the detector and can range from a few microseconds for miniature tubes, to over 1000 microseconds for large volume devices.

When making absolute measurements it is important to compensate for dead time losses at higher counting rates. If the resolving time of the detector is known, the true counting rate may be calculated from the measured rate using the following expression:

$$n = m / (1 - mt)$$

where n is the true counting rate, m the measured rate, and t the detector resolving time.

If the detector resolving time is unknown, it may be determined experimentally using two radioactive sources. Maintaining constant counting geometry is important throughout the experiment. A special source split into two halves is available for making the measurement, but good results may be obtained by careful positioning of two standard check sources. With the high voltage correctly set for the GM tube, position the two sources ($a+b$) side by side to obtain a count rate of at least 10,000 cpm. Accurately record the count rate as $R(a+b)$. Remove source (b) and record the count rate as $R(a)$. Carefully replace source (b) to its original position, remove source (a) and record the count rate of source (b) as $R(b)$. The resolving time is given by

$$T = \frac{R(a)+R(b)-R(a+b)}{2R(a).R(b)}$$

The resolving time of the ST250 Ratemeter is dependant on the range selected and is not a significant factor when making normal comparative measurements.

Serial Data Link.

Your ST250 Ratemeter contains a unique Data Link making it possible to connect the instrument to a personal computer for recording events. Data transfers are via a

RS-232C serial link and requires connection through a standard 9-pin cable to the computer COM 1 or COM 2 port. The ST250 Emulation Software may be run directly from the floppy disk supplied, or copied onto a hard drive if preferred.

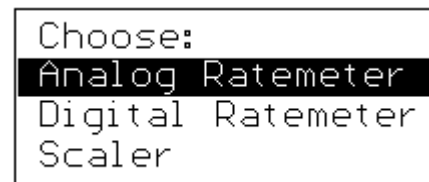
To run the software, enter the command line **RADEM250.EXE**. The program will self configure to the graphics system in use. Select the appropriate COM port.



Your system will now be configured for 9600 Baud data transfer and ready for use.

Software Emulator.

the ST250 software emulator greatly expands the capability of the ratemeter by providing large screen displays combined with multi-mode operation. Three basic modes are included.



Operation of the software is straightforward and requires little explanation.

The analog ratemeter mode provides a large screen display of the instrument meter which can be very useful for classroom demonstrations of basic radioactivity. Use the spacebar to switch the display between CPM and CPS, and the up/down arrows to change the range. For more precise readings, the digital ratemeter mode may be preferred for some measurements.

When operating in the scaler mode, all radiation events detected by the GM tube will be recorded during the pre-selected time. This mode greatly expands the usefulness of the ST250 by providing precise measurements of radiation. Use F1 to initialize the PRESET TIME mode and enter the required counting time in seconds. Entering zero or blank will allow the unit to operate in a manual mode. The scaler is started and stopped using the return key and the elapsed counting time is displayed in seconds.

At the completion of a preset time, the counting data together with the computer time of day clock is automatically stored in a data file which is displayed on the screen as a table. A new count may be restarted by simply pressing the return key, at which time the data register and elapsed time will automatically be reset, and the next run started. The counting may be interrupted at any time and resumed using the return key without loss of data providing the data is not stored in the data file. To store data in the manual mode, stop the counting and press the space bar. This action will cause the registers to reset when counting is restarted.

The ST250 software includes a recycle mode which can be very useful when performing radioactive decay such as half life experiments or absorption studies. Use the F1 key to select the required time for each count and the F2 key to set the number of measurements. Once started, the ST250 will now automatically store the data at the completion of each counting sequence, reset the registers, and continue for the number of runs selected.

Data File is a unique and powerful feature of SPECTECH products. Count and time data is stored in a tab separated temporary file which is displayed as a table. This may be stored as a .TSV file on the disk at the completion of a series of measurements. The file is compatible with many popular spreadsheet programs and may be directly transferred in the spreadsheet for analysis and viewing. At the end of a series of measurements use the ESC. key to prompt for file storage. If no filename extension is given the system will default to .TSV. To simply print the contents of the temporary data file, use the ALT_P keyboard command.

Run	Voltage	Count	Elapsed	Time Of Day
1	500	0	30	4:55:21 PM
2	525	0	30	4:55:52 PM
3	550	0	30	4:56:22 PM
4	575	0	30	4:56:53 PM
5	600	442	30	4:57:23 PM
6	625	3949	30	4:57:54 PM
7	650	4305	30	4:58:25 PM
8	675	4332	30	4:58:55 PM
9	700	4539	30	4:59:26 PM
10	725	4694	30	4:59:57 PM
11	750	4681	30	5:00:28 PM
12	775	4833	30	5:00:59 PM
13	800	4927	30	5:01:30 PM

Applications

In its basic configuration, battery operation and the ability to interchange GM probes allows the ST250 to be used for a variety of applications some of which are listed below.

Surface contamination measurement.

Personnel monitoring.

Plotting a GM plateau.

Radiation background measurement.

GM resolving time.

Radiation absorption studies.

Inverse square law.

Isotope half life.

Radiation properties.

Counting statistics.

When used with the Data Link and Emulator, more precise measurements are possible. In the scaler mode, low level activity may be accurately determined by increasing the counting time to reduce statistical variations. Using this mode, some of the above measurements may be performed more accurately along with low level environmental measurements natural radioactivity. Detector backgrounds may be effectively lowered by completely surrounding the GM probe with 1"-2" of lead, thus improving the lower detection limit.

Maintenance**CAUTION**

Dangerous voltages can exist inside the ST250 from the high voltage power supply. Before removing the cover ensure the instrument is in the OFF position and the high voltage is set to zero. Only qualified technicians should attempt any repairs.

Your ST250 has been built with care using quality parts and should not require any routine service. In the unlikely event of a malfunction, the unit may be returned to the factory for repair. We will gladly supply a cost estimate if the warranty period has expired.

Battery replacement is straightforward and involves removing the rear cover which is held in place by four screws. Ensure **the instrument is in the OFF position and the high voltage set to zero!** Replacement requires standard AA size **Nickel-Cadmium** batteries, preferably with a 500 mAh rating.

A complete list of parts is included for your convenience. Please contact our customer service department for pricing and availability. In many instances substitute parts may be used providing they meet or exceed the original specifications.

Circuit Description.**Low Voltage Power Supply.**

A high efficiency step-up switching regulator (U1) is used to produce power for running the instrument. This regulator generates +5 volts from the internal battery or the charger and provides sufficient current to recharge the batteries. It also monitors the battery voltage and produces a LOW Battery warning if the voltage falls below +2.6 volts. Charging current is established by D4 and is set at a 12 hour rate when the charger is connected.

High Voltage Power Supply.

High voltage is produced by a 17kHz pulse generator (U3) driving a step-up transformer through current switch (Q6). Output pulses from the transformer (400v max.) are tripled and filtered by diode pumps (D5-D9), and produce up to 1200 volts. Output voltage is controlled with the feedback loop (U2D) and (Q7).by comparison with the high voltage potentiometer setting and can produce stable voltages from 0 to 1200 volts with up to 100uA of available load current.

Ratemeter.

Negative pulses from the GM tube are coupled to the voltage comparator (U2A) through the high voltage decoupling capacitor (C16) and resistor (R30).The comparator threshold is set at approximately -300 mV, which is above the noise of most GM tubes. The comparator output triggers one-shot (Q2-Q4) to produce current pulses of fixed width determined by the range switch which are used to drive the meter. Capacitor (C13) provides integration and meter damping.

High Voltage Readout.

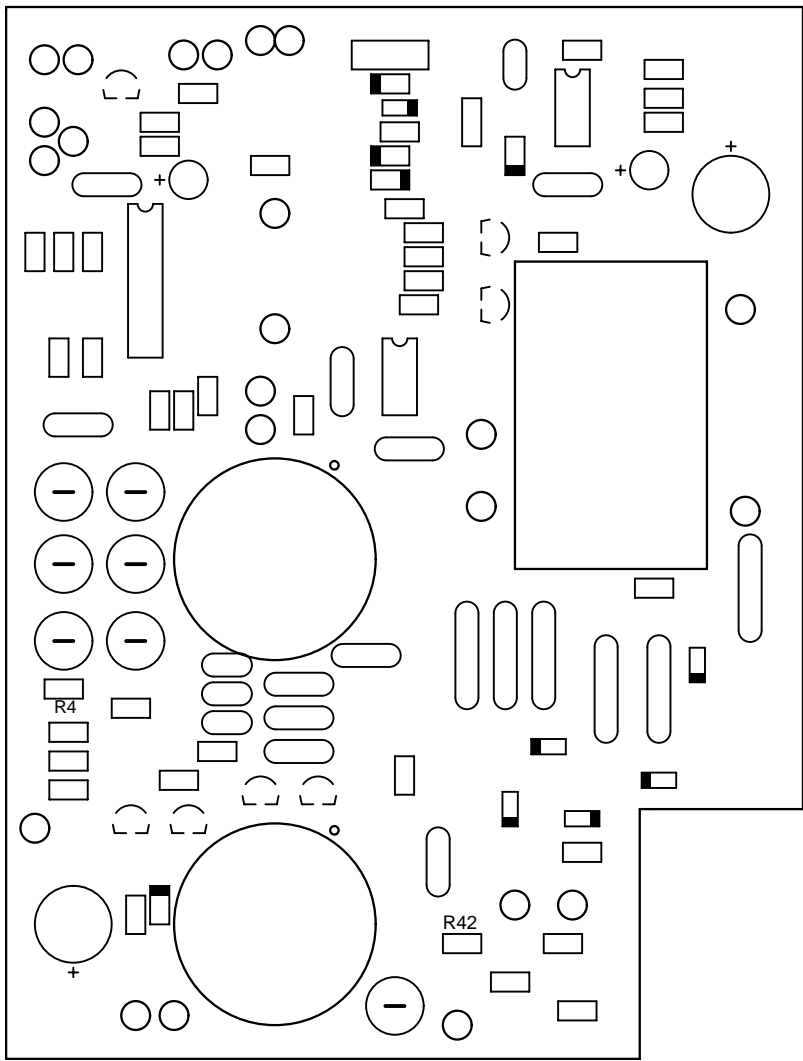
A percentage of the output high voltage is amplified by op. amp. (U2C) to produce a meter reading of the high volt setting through potentiometer (R31).

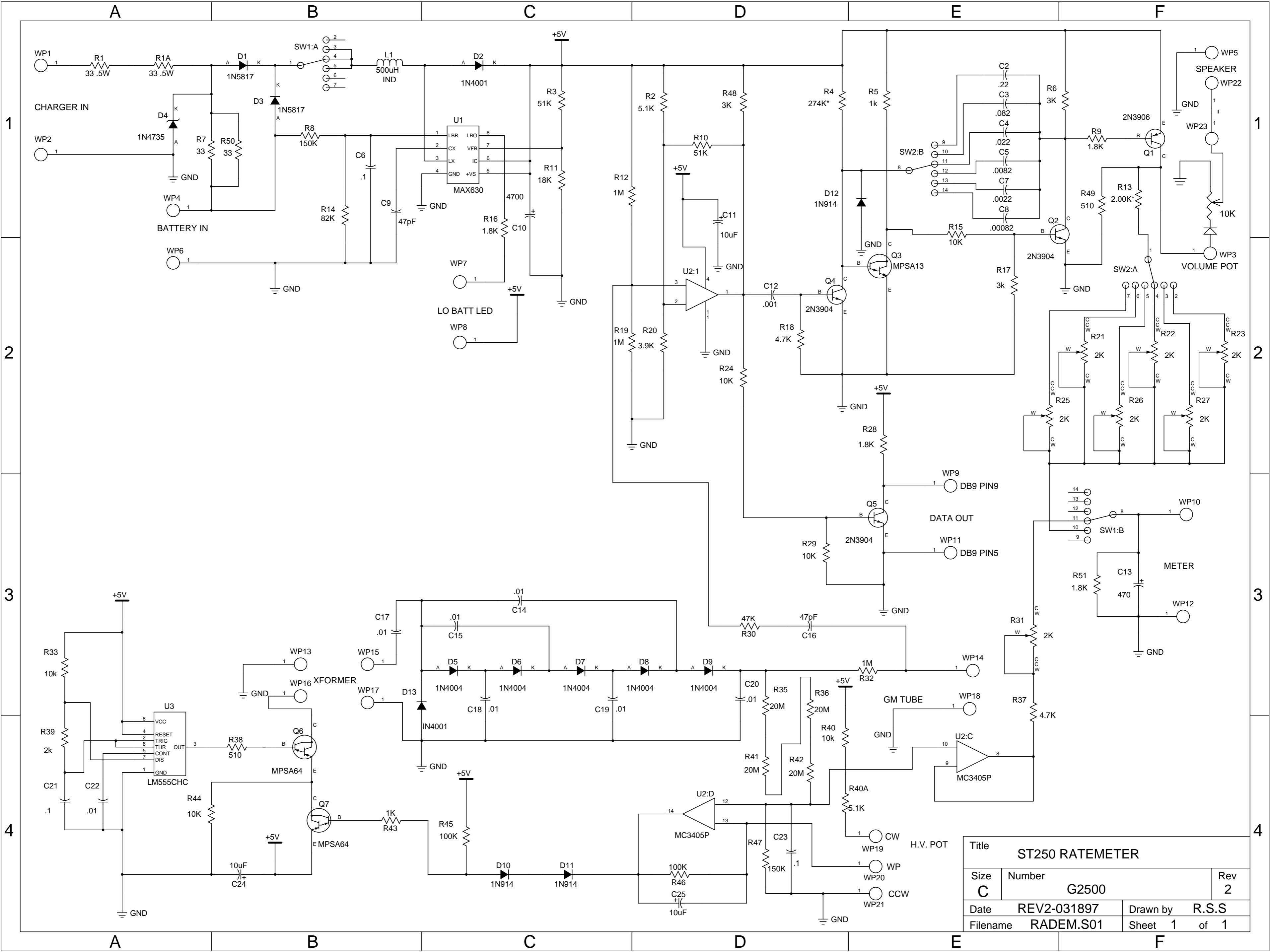
Calibration.

High voltage calibration is performed using a voltmeter with an input impedance of 100M Ω or greater and adjusting (R31), or by constructing a X10. divider with a 100M Ω resistor in series with a 10M Ω meter.

Range calibration is performed using a pulse generator of known pulse rate. Set the pulse to approx. -1v and 1 μ sec. duration (not critical) and adjust (R21-R27) sequentially to calibrate each range in turn.

Before connecting the pulse generator, ensure the high voltage is set to zero.





Title			ST250 RATEMETER		
Size	Number			Rev	
C	G2500			2	
Date	REV2-031897	Drawn by	R.S.S		
Filename	RADEM.S01	Sheet	1	of	1

Parts List.

Part	Description	Reference Designators
DA0001	Diode 1N4001, 100V	D2
DA004	Diode 1N4004, 400V	D5,D6,D7,D8,D9
DA006	Diode 1N4735, 6.2V Zener	D4
DA007	Diode 1N5817, Rectifier	D1,D3
DA008	Diode 1N914, general purpose	D10,D11
DL001	Diode HLMP-4700 LED	
TA001	Trans. MPSA64, Darlington PNP	Q7
TA004	Trans. MPSA13, Darlington NPN	Q3
TA002	Trans. 2N3904, NPN	Q2,Q4,Q5
TA003	Trans. 2N3906, PNP	Q1,Q6
IG002	Switching regulator MAX630	U1
IG001	Timer LM555CHC	U3
IA001	Amp./comp. MC3045P	U2
LL001	Choke 460uH, SL06-460-F	L1
LX001	Transformer Microtran M8050	
CB102	Capacitor .001uF, GE102K	C8
CB222	Capacitor .0022uF, GE222K	C21
CB332	Capacitor .0033uF, GE332K	C7,C4
CB103	Capacitor .01uF, GE103K	C5,C22
CB101	Capacitor 100pF, GP310	C23
CC104	Capacitor .1uF, M20R104K5	C1,C2,C3,C6
CD470	Capacitor 47pF, GP447	C9,C16
CE103	Capacitor .01uF, HS103M	C14,C15,C17,C18,C19,C20
CN100	Capacitor 10uF, electrolytic	C11,C24
CN472	Capacitor 4700uf, electrolytic	C10
CN471	Capacitor 470uF, electrolytic	C13
PA202	Potentiometer 2K, trimmer	R21,R22,R23,R25,R26,R27, R31
PB103	Potentiometer 10K, 10-Turn panel	
PC103	Potentiometer 10K, 1-Turn panel	
EA001	Piezo Alarm	
EC001	Connector DB-9P, serial	
EC002	Connector BNC panel mount	
EC004	Power Jack	
EC005	Connector battery holder	
EM001	Meter ST250 custom, 100uA	
MC001	Charger 7.5volt DC, 300mA	

Continued.

Part	Description	Reference Designator
AA202	Resistor 2K, ¼ W, 5%	R13
AA105	Resistor 1M, ¼W, 5%	R12,R19,R32,R46
AA182	Resistor 1.8K, ¼W, 5%	R9,R28,R16
AA302	Resistor 3K, ¼W, 5%	R5,R6
AA392	Resistor 3.9K, ¼W, 5%	R20
AA472	Resistor 4.7K, ¼W, 5%	R18
AA512	Resistor 5.1K, ¼W, 5%	R2,R48
AA103	Resistor 10K, ¼W, 5%	R15,R17,R24,R29,R43,R44
AA183	Resistor 18K, ¼W, 5%	R33
AA223	Resistor 22K, ¼W, 5%	R37
AA273	Resistor 27K, ¼W, 5%	R39
AA330	Resistor 33, ¼W, 5%	R7,R50
AA473	Resistor 47K, ¼W, 5%	R30,R11,R52
AA513	Resistor 51K, ¼W, 5%	R10
AA823	Resistor 82K, ¼W, 5%	R4
AA104	Resistor 100K, ¼W, 5%	R14,R45
AA124	Resistor 120K, ¼W, 5%	R8
AA154	Resistor 150K, ¼W, 5%	R47
AA274	Resistor 270K, ¼W, 5%	R3,R49,R51
AA511	Resistor 510, ¼W, 5%	R38
AB335	Resistor 3.3M, ¼W, 5%	R34
AB206	Resistor 20M, ¼W, 5%	R35,R36,R41,R42
AC330	Resistor 33, ½W, 5%	R1
ES001	Switch rotary, 2P-6POS	SW1,SW2
G2500	PC board, ST250	
HR250	Chassis ST250, rear	
HS250	Chassis ST250, front	
FC001	Clip GM35 Probe	
FC002	Clip GM25 Probe	
FC003	Battery Holder	
FC004	Clip battery	
FD001	Knob	
FB001	LED mount	
FH005	Handle	
FF001	Feet	
HS001	Jack Screw, DB-9	