Model ST365 Radiation Counter

ST365A Radiation Counter

The ST365 Radiation Counter combines many features into a single inexpensive instrument. We have expanded the classic nuclear scaler design to not only include a preset time function, a digital rate-meter, a digitally controlled high voltage supply, but now with computer interfacing via USB (COM port), LAN and Wi-Fi Direct formats.

The ST365 includes BNC and MHV connectors, and a precision high voltage supply that is adjustable from 0 to +1200 volts. This supply provides 0.2mA at 1200 volts making it suitable for many types of GM tubes and scintillation detectors.

The preset time function enables the user to acquire radioactive events for a predetermined number of seconds. This is necessary for accurately comparing radioactive sources.

The rate-meter function is ideal for contamination survey work and instantaneously displays the counts per minute (CPM) or counts per second (CPS).

The ST365 comes in two models. The ST365A with extra large LED's, provide a digital display that is clear and visible, even under bright ambient light or the ST365B with a back lit Liquid Crystal Display (LCD), provides the user with a more interactive interface.

The provided desktop computer software, **Spectrum Techniques Ultra**, enables classroom demonstrations of nuclear experiments. An instructor or students can run experiments on a wired connection from an IBM-PC compatible computer running Microsoft Windows or from a Mac Computer by a USB or LAN interface.

The **Spectrum Techniques Ultra** saves data spreadsheet compatible files and can graph the detector results during an experiment.

The **Spectrum Techniques Ultra** includes one mode that recycles counting after reaching a preset time and another mode that automatically increments the high voltage after each cycle. The first mode is useful for performing radioactive decay studies while the latter is useful for plotting detector plateaus.

Teachers and students can also down load the **Spectrum Techniques Ultra Mobile** for Android devices to allow instrument control and data display and capture.

Identifying Your Model

ST365A Seven Segment LED on left,

ST365B 16 Digit LCD on right.

Specifications

Inputs: BNC connector - Accepts standard Geiger tubes.
MHV connector - Accepts scintillation detectors.

High voltage: 0 to +1200 volts @ 0.2mA, selectable in 10 volt increments.

Model A Display: 6-decade LED, 1 in. numerals; mode LEDs

Model B Display: 16 Character LCD, Back light Alpha Numeric; mode LEDs

Modes: Counts; Elapsed Time; Preset Time; Count Rate (counts per second); High Voltage Level

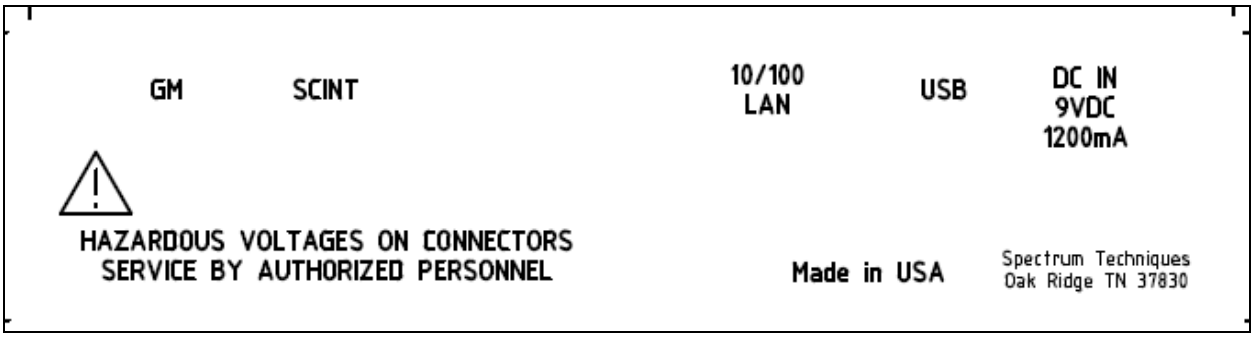
Interface: USB 2.0, and LAN for both PC and Macintosh . Wi-Fi Direct for Smart Phone

Power: 9 volt DC, at 1200mA*

Dimensions: 9 in. W, x 6.75 in D, x 3 in H

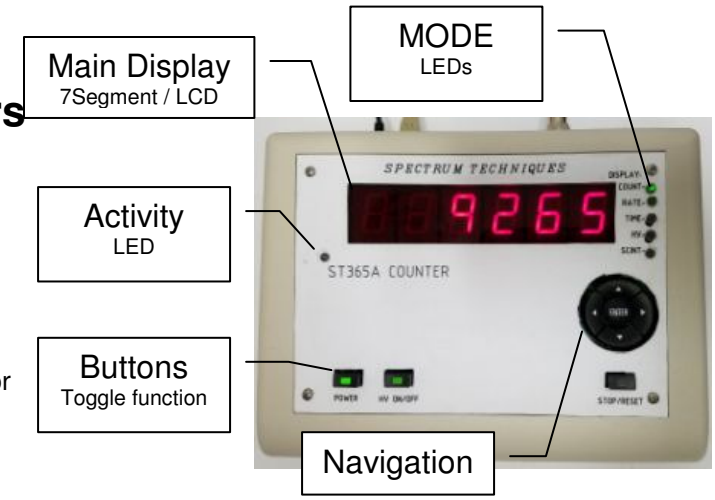
Software: Spectrum Techniques Ultra for desktop PC and Mac Computer, Spectrum Techniques Ultra Mobile for Android devices.

Caution: **Use only the AC adapter included with the ST365. Using a different adapter can damage the unit and void the warranty.**



Rear Panel Connections

Controls / Indicators



Below is a brief description of the ST365's front panel layout. A detailed explanation of the controls is in the following *Stand Alone Operating* section.

Main Display

Large digits to show the user set parameters or the measured data.

Mode Indication LEDs

The LEDs light to indicate the instrument mode selected by the user with the navigation controls.

ACTIVITY Indicator

When the instrument is in counting mode, the *ACTIVITY* LED on the left side of the display will indicate the when the unit is detecting and counting events.

POWER

Pressing the *POWER* button toggles the instrument on and off. An LED lights when the unit is powered.

HV ON/OFF

Pressing the *HV ON/OFF* button toggles the high voltage on and off. An LED lights in the button to indicate high voltage is on.

STOP /RESET

Pressing this button when counting will stop counting. While counting is stopped, pressing the button again resets the time and counts to zero.

Navigation Controls

The five navigation buttons allow the user to press up / down to select the instrument modes indicated by the LEDs COUNT, RATE, TIME, HV, SCINT and to press left / right to parameter values. Once the parameters have been set, press the center button to begin counting.

Stand Alone Operation

The ST365 can be remotely controlled by a USB, LAN or Wi-Fi interface using the Spectrum Techniques Ultra or Spectrum Techniques Ultra Mobile. Remote control is described in separate documents.

This section describes Stand Alone Operation from the front panel.

Below is a description of each mode. The *Navigation Control* buttons allow the user to select up and down through the modes. To the right of the main display are MODE LEDs indicating the instrument mode. In standalone operation (not computer control), the user can navigate the modes at any time, without affecting the data or interrupting the count, even if the unit is counting.

> Note, except for the POWER button, when the Spectrum Techniques Ultra PC application or Spectrum Techniques Ultra Mobile controls the ST365, the front panel controls become locked out.

Main Display

As the user navigates the modes, the main display changes to reflect the user set parameters or the measured data. During counting the user can navigate modes and the main display will change without interrupting the count or affecting the count data.

COUNT Display Mode.

In *COUNT* mode the unit displays the number of radioactive events, or *counts*. During data acquisition, the display will increment with each event in real time. When in *COUNT* mode the **COUNT** LED will regularly flash. Note that while counting, this LED will flash regardless of the other selected mode displayed on the unit.

TIME Set and Display Mode

Let's define a few terms. Preset time is a parameter the user sets for the duration of counting. Elapsed time is the time since the start of counting.

On entering the *TIME* mode the main display first displays the preset parameter time. It is also used for setting the Preset Time. When selected, the *TIME* mode display shows the elapsed time, to the second, of the most recent data acquisition. If *LEFT* or *RIGHT* is pressed, the view will switch to the current *Preset Time*. The *Preset Time* function will allow the user to automatically count radiation events for a predetermined amount of time. To modify the *Preset Time* continue to press the *LEFT* or *RIGHT* arrow buttons and observe the change in the *Preset Time*. Pressing the LEFT or RIGHT arrows will modify the preset one second for each key press. Holding the LEFT or RIGHT buttons down will cause the Preset Time to advance rapidly. After 30 seconds the change rate increases again.

Pressing the *COUNT* button will cause radioactive events to be counted for the preset time value. Afterwards, counting will automatically stop. Pressing *COUNT* a second time will reset the counts and elapsed time to zero, and again accumulate events until reaching the preset time value. Counting can be interrupted using the *STOP* button, without losing current data or the time elapsed. Pressing the center navigation key will resume data acquisition for the remaining preset time. To stop the *Preset Time* function for an indefinite count, set the preset time to *zero*.

RATE Display Mode

In this mode the main display provides the instantaneous count rate in either counts-per-minute or counts-per-second. To choose CPM or CPS, press the LEFT and RIGHT arrow buttons while in the *RATE* display mode. Rate display is very useful for survey applications.

HIGH VOLTAGE Set Mode

This mode is for either displaying, or setting the high voltage level. The high voltage can be set to any value between 0 and 1200 volts in 10 volt increments using the *LEFT and RIGHT* arrow buttons. Starting a count or pressing *STOP*, or *RESET* buttons do not affect the high voltage setting.

SCINT Mode (SCINT/GM) Indicator

When this LED is on, the user can change the input detector type. For correct operation the user must set the ST365 Radiation Counter correctly for the type of detector to which it is connected. With the up down keys, navigate to light the SCINT LED. Press the left and right keys to set the instrument for either the “Scint” or “Geiger” detector. Inside the instrument you are selecting pulse shaping, gain and thresholds appropriate for these different detector types.

System Operation

Basic SCINT or GM Tube Setup and Operation

Warning!

Dangerous voltages can exist at the GM and SCINT connectors. Ensure that the high voltage is set to OFF (LED is not lit) or that the instrument is OFF before connecting or disconnecting a detector.

Caution:

Simultaneously connecting a GM tube and a scintillation detector to the ST365 will result in erroneous data. Only connect one at a time.

GM Handling Caution:

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.

Scintillator Handling Caution:

This scintillation detector has a plastic liner to provide protection from mechanical damage and contamination. The aluminum wall inside the well is very thin. Dropping a sample into the well without a liner in place may damage the well. This damage is not covered by warranty.

1. Connect the ST365 to its AC adapter.
2. Connect a one wire NaI PMT tube to the SCINT connector at the MHV connector. OR Connect a GM tube to the GM connector via a BNC cable.
3. Power on the instrument. Check and if necessary set the ST365 counter for the appropriate type of detector. The SCINT indicator will be in for Scintillator and off for GM tube. See the operating modes regarding the SCINT Mode LED above for setting instructions.
4. Enter the HIGH VOLTAGE mode and use the left and right data keys to set the high voltage to the recommended value for the detector tube.
5. Place the radioactive source close to the detector.
6. Using the Operating Mode information described above set the unit up to perform the desired function.
7. Press the COUNT button to start data acquisition, and the STOP/RESET button to halt data acquisition. If Preset Time is not being used, press STOP/RESET again to reset the elapsed time and data to zero.

GM Tube Operation

Geiger-Mueller tubes produce electrical pulses when ionizing radiation events occur within their sensitive volume. For proper operation, only run these detectors at the manufacturer's specified voltage. If the operating voltage for this is not known, then the experimenter must derive the voltage empirically by plotting a plateau (see below). 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.

GM Tube Plateau

The correct operating voltage for the Geiger-Mueller tube may be determined experimentally using a 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 while the high voltage is increasing linearly. Make a plateau chart by using a constant preset time to count a source for several *runs*, while increasing the high voltage by some constant amount after each *run*. The next section describs this process in detail.

Creating a GM Plateau Chart

Running the unit as stand-alone

1. Place the radioactive source in a fixed position close to the window or in the well of the detector.
2. Put the ST365 into *Count* mode and slowly increase the high voltage until the ACTIVITY LED begins to occasionally light. (See the Controls and Indicators section of this document to locate the LED.)
3. Set the Preset Time to 10 seconds and press *COUNT*.
4. When the preset time expires, record the counts and the high voltage setting.
5. Increase the voltage by about 10 or 20 volts and count the source again.
6. When the preset time expires, record the counts and the high voltage setting again.
7. Repeat steps 5 and 6 until you reach the upper limit voltage of the instrument.
8. Once you finish step 7, turn off or reduce the High Voltage.
9. Create an X-Y graph of the data, with “Y” being the Counts, and “X” being the voltage, and plot the chart.

The following illustration shows a typical detector plateau.

Notice that the counts form a relatively flat place on the graph between 850 and 1100 volts. The center of this area, at approximately 1000 volts, is the recommended operating voltage for the detector. However, any voltage in this flat region would be acceptable. Also, notice that the counts increase rapidly as the high voltage nears its upper limit. This indicates that the tube is entering its breakdown region. Do not continue to operate the tube in this region. Operation in the breakdown region will shorten the useful life of the tube.

Resolving Time

Geiger-Mueller tubes exhibit dead time effects due to the recombination time of internal gas ions after an ionizing event occurs. The actual dead time depends on several factors including the active volume and shape of the detector. Dead time 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 (Spectrum Techniques part # RSS-2) is available for making the measurement, but good results may be obtained by careful positioning of two standard check sources. Perform the following steps to calculate the resolving time:

1. Set the ST365 to *Rate* mode.
2. Position the two sources (***a+b***) side by side and close enough to the GM tube's window to obtain a count rate of at least 10,000 CPM.
3. Record the count rate as $R_{(a+b)}$.
4. Remove source (***b***) and record the count rate as $R_{(a)}$.
5. Carefully replace source (***b***) to its original position, remove source (***a***) and record the count rate of source (***b***) as $R_{(b)}$.

Solve for the resolving time using this equation $$T = \frac{R_{(a)}+R_{(b)}-R_{(a+b)}}{2R_{(a)}.R_{(b)}}$$

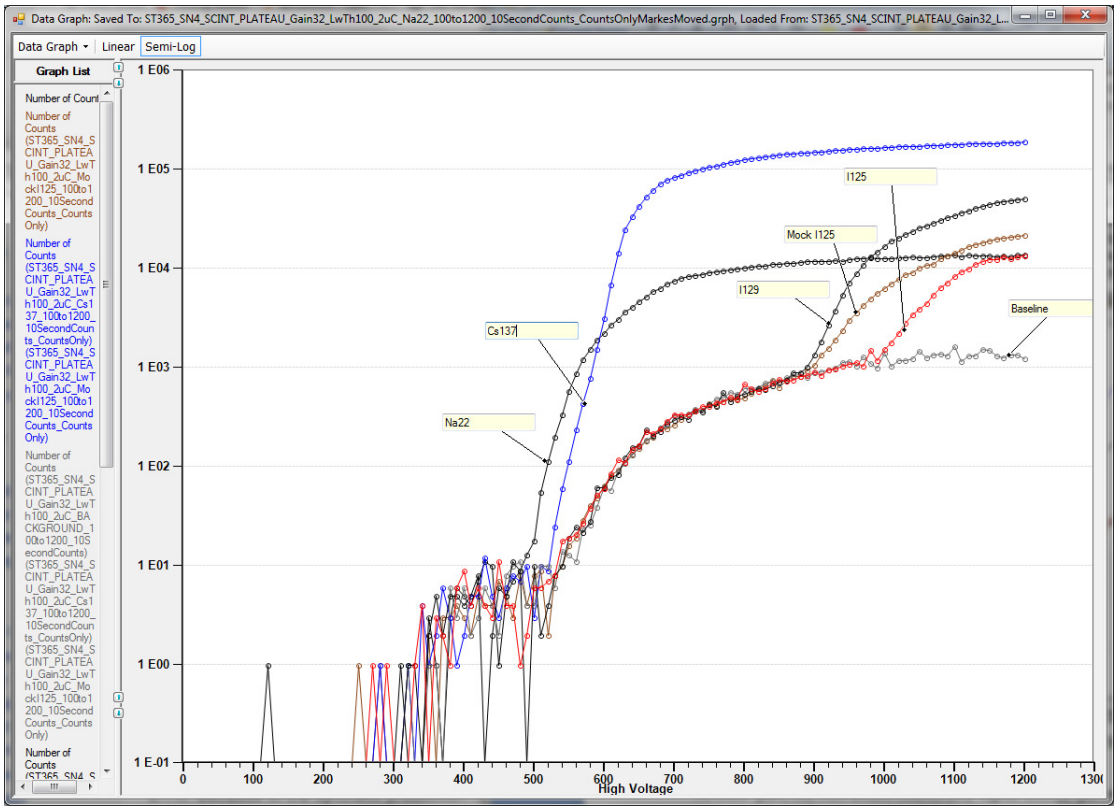
The resolving time of the ST365 RADIATION COUNTER is very short and is not a significant factor compared to that of the GM tube.

NaI PMT Operation

Scintillation detectors such as are comprised of a Sodium Iodide crystal and Photo Multiplier Tube (NaI PMT) produce electrical pulses proportional to the energy absorbed in the detecting element. The NaI crystal has good sensitivity to gamma radiation.

NaI PMT Gain Sweep

Unlike the plateau of the Geiger-Mueller tube, there is no such obvious “correct operating voltage” for the Photo Multiplier Tube (PMT) in the gamma radiation detection system. The ST365 sets the gain of the PMT by the high voltage it applies to the PMT. A higher voltage operates the PMT at a higher gain. By a choice of PMT voltage (PMT gain) the user can lean to approximate the energy of the detected gammas. Sweeping the PMT voltage with known energy samples demonstrates this.



Semi-Log of the counts of background, and various isotopes versus PMT voltage.

At lower HV (PMT gain), the instrument counts only higher energy gammas. Increase HV (PMT gain) brings lower energy gammas above the measurement base line. To establish a base line step the HV over the full range and plot the counts.

Isotope	**Gamma Energy**	**Note:**
Na22	1274.53 keV	Half life: 2.6 years
Cs137	661.657 keV	Half life: 30.07 years
I129	39.578 keV	Half life: 15.7 Million years
Mock I125		Composed of I129 and Am241 About 50-50
I125	35.492 keV	Half life: 59.49 days

Creating a PMT Gain Sweep Chart

The PMT voltage threshold for the instrument may be determined experimentally using a variety of known radioactive sources. In our example above we used several radioactive sources. Consider for example Cs137 and I125 with an almost 20:1 energy difference (662 keV/ 35keV). If you have such sources you may want to replicate the graph above with your sources. You will want to use the same count time for all samples. Your most active source will limit your count time to some maximum. Perform the following steps to calculate the maximum count time:

1. Set the ST365 to *COUNT* mode. Start by setting to count for 10 seconds.
2. Find your source with the highest count rate. Set the HV to maximum, 1200 Volts. Count each source for the same time. Find the sample with the highest count rate. Increase or decrease the count time to give a high reading practical reading and be careful not overflow the counter display. Record the sample type: _____ and the count time: _____. Set the instrument and use the same time for the measurement of the other samples and the background.
3. Take a background count. With no source in the detector well, measure the counts as a function of voltage. Start at the minimum and step the voltage to the maximum, recording the counts at each voltage step. You may want to graph the results as you go.
4. For each sample, repeat the actions of step 3 and, using the same voltage set points, record the counts at each voltage. You may want to graph the results as you go.

Hint: Copy the preceding page and plot your points on your copy.

Did you see for each sample a knee where the counts increased above the background?

The Wipe Test System

The ST365 Radiation Counter will also operate with NaI(Tl) scintillation tubes for detecting low-level gamma and X-ray emission from a variety of samples. The *Wipe-Test* system includes a well detector, base, cable, and lead shield for measuring wipes or tube samples.

This system will detect gamma and X-rays ranging in energy from 20 keV to several MeV. Each system is factory calibrated and should not require further adjustment unless a different detector or base is used. A Cs-137 calibration source is included for routine checking of overall system performance and quality assurance. The next section describes in detail the Wipe Test system setup, operation, and calibration.

The Wipe Test

The Wipe Test system should be set up in the following manner:

Checking the System Calibration

Use the supplied calibrated Cs-137 source to check the counting efficiency and overall system performance. This source has its activity marked in counts per minute (cpm) and the date of manufacture. Over time, the source decays with a half-life of 30.1 years and it will be necessary to periodically correct the activity.

1. Place the calibrated Cs-137 source into the plastic well-liner and into the well of the detector.
2. Set the *Preset Time* to 60 seconds and begin counting
3. After counting is finished, the reading should correspond within ±10% of the activity in cpm recorded on the source. For better accuracy, use the average of three separate readings.

Taking a Background Reading

Wipe tests are inherently low-level measurements and it is necessary to perform background subtraction on all samples to generate accurate activity data. Because the background reading is low, it should be counted for a longer period to improve the statistics.

1. Remove all radioactive material from the vicinity of the detector.
2. Set a preset time of 600 seconds and begin counting.
3. When counting is complete, record the value and divide it by 10 to derive the background counts per minute (cpm)

Measuring Wipes

1. Using the well-liner, position the sample into the well of the detector.
2. Set the preset time to 60 seconds and begin counting.
3. When counting is complete, record the count.
4. Subtract the background counts-per-minute and record the value. This is the correct counts/minute for the sample.

System Re-calibration

The system is calibrated at the factory, and under normal circumstances, recalibration should not be required. However, in the event of a detector or detector base replacement, it will be necessary to determine the correct operating voltage for the system. Using the Cs-137 source supplied with the system, refer to the section *Creating a Plateau Chart* to obtain the correct operating voltage

Warranty and Repair Information

Spectrum Techniques warrants products of our manufacture against defects in workmanship or material for a period of one year from date of shipment. We will repair or replace, at our option, any instrument that is deemed defective during this time. This warranty covers all replacement parts and labor. The instrument must be returned to our factory prepaid and we in turn will pay the cost of the return shipping.

The warranty does not cover damage caused by mishandling or misuse. GM tubes with broken windows are specifically excluded from this warranty. NaI detectors with damaged wells are specifically excluded from this warranty. Accessory items not manufactured by Spectrum Techniques but supplied as part of our systems will be subject to the original manufacturer's warranty.

For warranty-repair information or return authorization, contact customer service at:

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