SYSTEM CONTROLLER

MODEL SC-755

OPERATING AND SERVICE MANUAL

Version 1.20z

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TSA systems

SC-755

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1. INTRODUCTION

1.1. SCOPE AND PURPOSE OF MANUAL

This manual is designed to enable operating and service personnel to properly operate and care for the SC-755. Since applications are necessarily site-specific, operation procedures are given in general terms. Service and repair are covered to the board level. Anything more complex than this requires that the instrument or assembly be returned to TSA.

1.2. GENERAL DESCRIPTION

TSA's System Controller, Model SC-755, is a general purpose controller module. The SC-755 was designed primarily for use in portal monitor systems, but is versatile enough to be used in other applications. The SC-755 contains:

one microcontroller
two amplifier/SCA channels
one high voltage power supply
four counter channels

The SC-755 is referred to as the master controller.

A four line, twenty character LCD display is used to monitor system status and set up information. Set up is accomplished using the twelve key, telephone style keypad mounted on the front of the unit, or using the Windows™ based program included with the instrument All of the settings and system status are stored in non-volatile RAM internal to the instrument. The status information can be downloaded using the Windows™ based program.

The SC-755 is calibrated and programmed with default values before being shipped from the factory. Final set up is necessarily site specific, and should be optimized to meet local requirements.

The unit has a base time interval of 200ms. All internal timing is based on this interval. The number of base intervals used in the moving average may be programmed. The alarm comparisons are performed every 200ms when the system is occupied.

The system also logs system activity to non-volatile RAM. Each entry is time and date stamped. Events that are logged to NVRAM include: hourly background updates, tamper alarms, background alarms, and radiation alarms. The NVRAM may be downloaded to a PC via the RS-232 port.

The controller is mounted in 9"h x 4.5"w x 3"d (22.5 x 11.3 x 7.5cm) polycarbonate enclosure.

Connectors are provided for dc input, all of the input/output signals, and RS-232 output.

1.3. SPECIFICATIONS

Display:	LCD, 4 lines x 20 characters
Key Pad:	Twelve key, telephone style
Communications:	DB-9F connector for interface to a PC using the Windows™ based communications program
Power:	Power Requirements: 9 – 15 Vdc, ≈ 200 ma High Voltage Power Supply: Up to 1,500 Vdc, ≈ 50µA Input Power: 10 - 16 volts dc, at <200 mA
Amplifiers:	Two nuclear pulse amplifiers with discriminator and SCA outputs
Counter Channels:	Four digital counter channels
Input Connectors:	Two BN connectors for detector signal inputs, circular connector for digital inputs from an SCA-725
Output Connectors:	Two MHV connectors for detector high voltage, circular connector for power and control signals to an SCA-725, relay outputs for status to external indicators
Dimensions:	9"h x 4.5"w x 3"d (22.5 x 11.3 x 7.5cm)

Weight: 3 lb (1.3kg)

Environmental:

Temperature: -30˚ to 122˚F (-34˚ to 50˚C); designed for use in a sheltered area

Humidity: Up to 95% non-condensing

NOTE:

Some of the features are not used in all configurations.

2. INSPECTION AND INSTALLATION

The following procedures should allow on-site personnel to correctly install and set up the SC-755 for normal operation. Follow the procedures in the order given. It is recommended that a copy of the Initial Installation Checklist (section 2.3.) be filled out after initial installation and whenever the SC-755 is put into service after prolonged storage.

If necessary, consult TSA Systems for assistance in case of unusual site conditions or special requirements.

2.1. INSPECTION

2.1.1. Incoming Inspection:

Immediately inspect the instrument for mechanical damage, scratches, dents or other defects. It should be examined for evidence of concealed, as well as external damage.

2.1.2. Damage Claims:

If the instrument is damaged in transit or fails to meet specifications upon receipt, notify the carrier and TSA Systems immediately. Shipping cartons, packing materials, waybills and other such documentation should be preserved for the carrier's inspection. TSA will assist in providing replacement or repair of the instrument if necessary.

2.1.3. Storage:

If the instrument is to be stored for any length of time, first disconnect power to the instrument and remove and store any batteries separately in a cool place. If batteries are to be stored for any length of time, they should be inspected and charged if necessary at least once a month. Care should always be taken to avoid subjecting the instrument to severe mechanical or environmental shock. The instrument should be stored in a dry, temperature constant location.

2.1.4. Shipping:

Before returning the instrument for any reason, notify TSA Systems of the difficulty encountered, giving the model and serial numbers of the equipment. TSA will furnish specific shipping instructions.

2.2. INSTALLATION

2.2.1. Wiring Assignments:

Refer to "SC-755 Wiring Diagram" Drawing 2, "SC-755 Board Schematic Diagram" Drawing 4 and "SC-755 Board Component Designator" Drawing 5 (Appendix F.).

NOTE:

All wiring should be done in compliance with local electrical codes.

The controller is shipped with pigtail connectors for power and data signals, the wire assignments are:

SC-755 EJ1		
Pin #	**Signal**	**Color**
1	+10 - 16 Vdc input	Red
2	Common	Black
3	Occupancy	Green
4	Tamper input	White
5	Channel 3 input (from SCA-725)	Orange
6	Channel 4 input (from SCA-725)	Yellow
7	Data Output (to SCA-725)	Blue
8	Shift Clock Out (to SCA-725)	Violet
9	Select Device 0 (to SCA-725)	Brown

SC-755 EJ2				
Pin #		**Signal**		**Color**
1		Radiation Alarm (NO)		Brown
2		Radiation Alarm (NC)		Not wired
3		Radiation Alarm (common)		Green
4		High Background (common)		Blue
5		High Background (NC)		Not wired
6		High Background (NO)		Blue
7		Low Background (common)		Orange
8		Low Background (NC)		Not wired
9		Low Background (NO)		White
10		Not used		

If necessary, consult TSA Systems for assistance in case of unusual site conditions or requirements.

Turn the instrument on and test the controls, display and alarm according to the steps outlined in Power-Up and Self-Test (section 3.1.). While the instrument comes from the factory tuned and calibrated, the calibration should be verified before putting the instrument into service.

CAUTION:

AC power and alarm outputs are run through a user-supplied conduit. This conduit must be watertight if the system is to be installed outdoors.

2.3. INITIAL INSTALLATION CHECKLIST

___ Incoming inspection performed by: _____

___ 9 - 15 Vdc power source available.

___ Input/output connections properly wired

___ System calibration:

Master: LLD set to: _____ ULD set to: _____

Slave: LLD set to: _____ ULD set to: _____

Parameter settings:

Number of Detectors set to: _____

Low Alarm level set to: _____

High Alarm level set to: _____

Occupancy hold-in set to: _____

Alarm Comparison Intervals set to: _____

Alarm level (N*Sigma) set to: _____

___ Electronic calibration required: SC-755: _____ HHV-448: _____

___ System starts up and runs initial self-test without errors.

___ All modes operational

___ Background mode in operation area; count = _____

___ Variance test; variance detector 1: _____ 2: _____ 3: _____ 4: _____

___ Sensitivity test; list isotopes, activity and serial number of sources used:

_____

Performed by: _____ Date: _____

3. OPERATING INSTRUCTIONS

3.1. POWER-UP AND SELF TEST

Turn on the power switch located on the right side of the SC-755. The instrument will reset and clear the system, then perform a Power On Self Test (POST) (section 5.2.1.) which takes approximately ten seconds The tests are displayed on the screen as they are run. If any test fails, the system will be halted.

NOTE:
The problem must be corrected before operation can commence.

Toward the end of the test series, the alarm relays will be energized for about four seconds. If all the tests have been completed successfully the system will go into the count mode.

When the background is complete, system status will be displayed. The status screen consists of four lines:

BKG = nnnn (background or COUNT, in cps)
OK (system status, OK, TAMPER, OCCUPIED)
BATT: nn.nn (battery voltage)
mm/dd/yy hh:mm (date and time)

The system is now ready for set- up and programming.

3.2. SET-UP AND PROGRAMMING

The SC-755 is a general purpose controller which is keypad programmable, making it extremely versatile so that it may be used for a wide variety of applications. To program the SC-755, refer to Programming the System (section 3.4).

The controller is calibrated and tested at the factory, but it must be set up to operate with the customer's equipment in the field.

Calibration should be performed using the Field Calibration Procedures in (section 6.1) as a general guideline. The procedures in (section 6.1) are for a general purpose portal monitor like the PM-700A. The pulse amplitude may be set to meet the requirements of most systems.

3.3. PASSWORD CONTROL

The zero key on the keypad is used to enter the set-up mode from the operating screen. Before the menus can be accessed, the password must be input, followed by the pound (#) key.

If the password is not entered correctly, the system will return to the operating screen.

NOTE:
The password is set to "1234" and can not be changed.

3.4. PROGRAMMING THE SYSTEM

CAUTION:
Always verify the calibration before attempting to program the system.

All of the system parameters are controlled from the SC-755 controller.

The SC-755 has a telephone style, twelve-key keypad on the front panel. Using this keypad, the operator can perform system set-up and diagnostic tests.

After the system has been powered up, and the initial background has been acquired, the set-up menu can be accessed. The set-up menu presents the operator with a choice of parameters, diagnostic functions and advanced calculations and test options. The set-up menu is protected by password access.

SET-UP MENU
Parameters
Functions
Advanced

Section 3.4.1. Parameters describes the five available parameters.
Section 3.4.2. Functions describes the six available functions
Section 3.4.3. Advanced describes the seven available advanced calculations and test options.

- Pressing the one key permits the operator to access the Parameters menu.
- Pressing the two key permits the operator to access the Function menu.
- Pressing the three key permits the operator to access the Advanced calculations menu.
- Pressing the zero key will display the next page of the current menu, where appropriate.
- Pressing the pound (#) key will return to the main menu from the sub menus, or return to normal operation if it is pressed at the main set-up menu.

3.4.1. Parameters:

Pressing the "one" key on the Set-Up menu will present a menu of the available parameters.

PARAMETERS		
1.	HI/LO LEVELS	Background alarm levels
2.	INTERVALS	Number of 200ms intervals per comparison
3.	OCCUP HOLDIN	Number of 200ms intervals to hold in after occupancy
4.	NSIGMA	N*sigma radiation alarm level
5.	DET. ONLINE	Number and position of detectors in the system

- When a parameter is shown with a "NEW=" prompt below it, a new value may be entered from the keypad.
- Pressing the asterisk (*) key clears the current operator entry.
- Pressing the pound (#) key accepts the current value, or the new value that has been entered by the operator.

3.4.1.1. Hi/Lo levels:

The Hi/Lo parameter sets the low and high background alarm levels, in cps per detector. If the counts fall outside this window, the system will indicate a background fault, and not allow further operation until the problem is corrected.

These levels should be set to alarm level if the average background deviates too far from normal. These alarms are intended to flag a failure in the detector or electronics. The precise settings will vary with local conditions and requirements, but a good starting point is usually 50% of the average background for the low and 150% of the average background for the high.

3.4.1.2. Intervals:

The Intervals parameter actually controls two functions:

1. The number of 200 ms intervals to "look back" after the system detects occupancy.

2. The number of 200 ms intervals that are used for each alarm comparison.

This feature prevents a person approaching the portal from affecting the background. The factory setting is 5 intervals (one second), but the optimum setting may vary with local conditions.

3.4.1.3. Occup Holdin:

The Occupancy Hold In parameter identifies the number of 200ms intervals to hold in after the occupancy signal indicating the system is vacant. This prevents the person from attenuating the background. The factory setting is 3 intervals (600 milliseconds), but the optimum setting may vary with local conditions.

3.4.1.4. NsigmaA:

The N*sigma parameter sets N*sigma radiation alarm level. Where N is the number entered and sigma = 1background in cps. This formula determines the number of counts, above background, that will trigger a radiation alarm.

3.4.1.5. Det. Online:

The Det Online parameter indicates the number and position of detectors in the system. The SC-755 will support up to four detector inputs. If less than four detectors are installed in a system, the unused inputs must be disabled to allow proper system operation. The detectors on line will normally display "1234". To disable an individual detector, type a zero in its position. For example: typing "1034", would disable detector number 2, the detectors on line would display 1_34. To enable all four detector inputs (the normal setting for a PM-700 system) enter "1234", the detectors on line will display "1234".

3.4.2. Functions

Pressing the "two" key on the Set-Up menu will present a menu of the available functions.

FUNCTIONS		
1.	SHOW COUNT	Displays detector counts
2.	DSCR. ADJUST	Discriminator adjustment
3.	VARIANCE	Performs variance test on all detectors
4.	SET CLOCK	Sets system time and date
5.	BAUD RATE	Sets baud rate for RS-232 communications
6.	Show Version	Displays the software version number

3.4.2.1.Show Count:

The Show Count function displays detector counts, in cps, updated once per second. All alarms are disabled in the show count mode. Press the pound (#) key to exit the show count mode.

3.4.2.2. Dscr. Adjust:

The Discriminator Adjust function opens the menu to adjust the LLD and ULD.

The discriminators set the energy levels at which the system will be accept counts. If the isotopes are unknown, leaving the discriminators set at the factory defaults of 0.098 and 5.040 volts is normally acceptable.

When the system is shipped from the factory, the discriminators are normally set to accept energy in the approximate range of 40 keV to 1.6 MeV. The settings are necessarily site specific, and may require adjustment to meet local requirements. The relationship of discriminator voltage to energy level, in keV, is approximately 1 volt of discriminator level equals 330 keV. Using this formula, the factory settings equal:

LLD 0.098 volts = 32 keV

ULD 5.040 volts = 1,663 keV

For SNM applications, setting the LLD at 0.068 (approximately 22 keV) and the ULD at 0.455 (approximately 144 keV) will provide maximum sensitivity and minimize nuisance alarms.

This relationship is an approximation. In practice, the actual values will vary slightly. Always test the system with the isotope(s) of interest to ensure maximum sensitivity. Refer to the formula for signal to background ratio in Appendix C. Formulas for details on optimizing the discriminator settings for specific isotopes.

NOTE:
After changing the discriminator settings, always run a variance test (6.2.) to ensure that system noise is not affecting the count data. Refer to Formulas (Appendix C.)

Two methods of adjustment are provided:

1. Direct entry:

   Press the zero key from the "ADJUST ULD/LLD" menu. The operator will be prompted for a new LLD setting. Enter the new value, the first digit entered is volts, the second digit entered is tenths of a volt, etc., and press the pound (#) key, or simply press the pound (#) key to accept the current setting.

   NOTE:
   Since the DACs have limited resolution, manual entries will be rounded to nearest value the DACs can output.

Once the pound (#) key has been pressed, the ULD menu will be presented. Use the same method to set the ULD. This sets the discriminator levels for the master pillar. After the discriminators in the master pillar have been set, the menu heading will change to "REMOTE ULD/LLD".

Repeat the above process to set the discriminators for the slave pillars.

2. Manual adjustment:

At the "ADJUST ULD/LLD" menu, the discriminators may be adjusted one step at a time while observing the count from both detectors. The following keys are used:

1 increments the LLD by one step (approximately 0.0098 volts)
7 decrements the LLD by one step
3 increments the ULD by one step (approximately 0.0196 volts)
9 decrements the ULD by one step

When the settings are satisfactory, press the pound (#) key to accept the settings and access the menu for the slave pillar.

The display will change from "ADJUST ULD/LLD" to "REMOTE ADJUST" to indicate that the discriminators in the slave pillar are ready to be adjusted.

Repeat the process for the slave pillar.

Pressing the asterisk (*) key at either the master or slave screen will load the default discriminator settings:

LLD = 0.098
ULD = 5.040

3.4.2.3. Variance:

The Variance function performs a variance test on all detectors. The SC-755 runs 15 second variance passes. In the PM-700A system, TSA recommends running five, 15 second passes. After five passes all variance readings should be less than 0.15. Refer to Formulas (Appendix C.) for further detail on the variance test and the formulas used. Press the pound (#) key to terminate the variance test.

NOTE:

The variance for a detector that is disabled will be 99.00.

3.4.2.4. Set Clock:

The Set Clock function sets the system time and date. The operator will be prompted to enter the hours (in 24 hour format), minutes, month, date, and year (last two digits only) from the keypad.

When the pound (#) key is pressed after the last entry, the data is written to the internal clock/calendar.

3.4.2.5. Baud Rate:

The Baud Rate function sets baud rate for RS-232 communications.

Valid entries are: 1200, 2400, 4800, and 9600 bps.
Other communications parameters are: no parity, eight bit data, and one stop bit.

Perform a variance analyzer test (section 6.2), and a walk-through test (section 6.3.) with a source before the unit is put into operation. For more information and recommended settings for different SNM types call TSA's engineering staff.

3.4.2.6. Show Version:

The Show Version function displays the version of the installed software.

3.4.3. Advanced:

Pressing the "3" key on the Set-Up menu will present a menu of the advanced functions.

ADVANCED				
1.		ALGORITHM		Selects specific detectors
2.		BKG TIME		Sets initial background time
3.		SHOW VERSION		Displays version of installed software
4.		CLEAR CNTS		Counts occupancies and alarms
5.		F-ALARM TEST		Test false alarm mode
		BKG.NSIGMA		Sets sigma value for throw-through alarm
		SYSTEM ID		Assigns identification number to the system

3.4.3.1. Algorithm:

The Algorithm mode permits the operator to select which detectors will be included in the alarm calculations. This allows the operator to optimize system operation for the local conditions. When this mode is selected, the selections will be presented on the display one at a time.

Pressing any key, except the <#> will toggle the calculation on and off. To accept the current setting, press the <#> key to step to the next selection. The available selections are:

SUM:	Tests the sum of all detectors in the system (usually four)
HORIZ:	Tests the sum of the two top detectors and two bottom detectors
VERT:	Tests the sum of the upper and lower detectors in each pillar
SINGLE:	Tests each detector individually

3.4.3.2. Bkg Time:

The Bkg Time mode sets the initial background time for the system. Press <1> to increment the time by 5 seconds, 7 to decrement the time by 5 seconds. Press <#> to accept the setting. Range is 20 - 120 seconds.

3.4.3.3. Show Version:

The Show Version mode displays the version of the installed software.

3.4.3.4. Clear Cnts:

The SC-755 counts the number of occupancies and alarms since it was turned on. These numbers are displayed here. The counter may be cleared pressing <1>. Any other key exits this mode without clearing the counters.

3.4.3.5. F-Alarm Test:

The F-Alarm Test mode provides a convenient means to test false alarms versus occupancies. Enter <1> to select the number of trials. The range is 1 to 32,000, or 0 for continuous testing. Enter <2> to exit this mode without testing.

The false alarm routine takes a 30 second background, 60 seconds of occupancies. Each occupancy is for three seconds. After twenty occupancies, the system acquires a new background. The number of occupancies and number of alarms are displayed as the data is collected.

The display looks like this:

F-ALARM TEST
TRIALS= nnnnnn
ALARMS= nnnnnn
MODE= BKG, OCC, DONE

When MODE=DONE, press a <#> to exit the routine and erase the numbers.

Pressing the <#> key while the test is in progress will terminate the test. Pressing the <#> key a second time will exit the test mode and reset the system.

3.4.3.6. Bkg.Nsigma:

The Bkg Nsigma mode sets a sigma value for a "throw-through alarm". This alarm runs continuously in the background mode to ensure that a source is not thrown through the monitor without occupancy being sensed.

Throw-through alarm comparisons are performed every 200 ms during background mode. The range is from 0.0 to 99.9. Setting the value to 0.0 will disable this feature. A very high false alarm rate can occur if this value is set too low. Test the unit after enabling this feature.

3.4.3.7. System ID:

The System ID mode assigns an identification number to the system. This number is used to uniquely identify the system to one or more PC’s. This number must be used by the PC to establish a communications link. The range of this number is from 1 to 32,767.

4. PC COMMUNICATIONS

The SC-755-PRT is designed to output count data via the RS-232 port once per second. This communication is output only, and the controller will not respond to external inputs.

The baud rate may be set from 1200 to 9600, 8 data bits, no parity, and 1 stop bit.

The data is output in standard ASCII text, count 1, count 2, <cr><lf>.

5. THEORY OF OPERATION

5.1. OVERVIEW

The SC-755-PRT software merely transmits count data once per second. No alarm comparisons are performed, and many of the functions of the standard software are not implemented. Counts are accumulated every 250 ms, and the most recent one second total is transmitted via the RS-232 port. This process continues as long as the controller is on, except when it is in the set-up mode.

5.2. MODES

5.2.1. Self Test Mode:

When the instrument is turned on, it performs a Power-On Self Test (POST). The POST performs the following tests:

RAM (Random Access Memory):

Tests conventional memory, primarily the area used for the processor's stack

NVRAM (Non-Volatile Random Access Memory):

Tests the battery-backed, non-volatile memory used to store parameters, and downloadable data

Lamps:

The audio annunciator and both lamps are turned on for approximately 4 seconds.

If any of these tests fails, the SC-755 will display a "FAIL" message.

NOTE:

The system cannot be put into service until the problem is corrected.

NOTE:
The relay contacts are not tested automatically. The operator must verify proper operation of any external equipment which utilizes the relay outputs.

After completing the POST, the system will enter the count mode.

5.2.2. Variance Analyzer Mode:
In this mode, the unit takes 75 counts of 0.2 second background data and performs a variance calculation on the data. A more detailed description of the variance test may be found in Formulas (Appendix C.).

5.3. COMPONENTS

The SC-755 is made up of the following five components:

5.3.1. SC-755 Board:
Refer to "SC-755 Board Schematic Diagram" Drawing 4 and "SC-75 Board Component Designator" Drawing 5 (Appendix F.).

The SC-755 board is the computer board for the system. It uses program software to run the unit and perform all functions. It also contains two SCA channels that amplify and digitize the signal from the detectors in the master controller.

The SC-755 receives 10 - 16 Vdc, and uses a dc-dc converter to supply the ±5 Vdc required by its own board circuitry.

The digital portion of the SC-755 board uses highly integrated components.

NOTE:
If a failure occurs in the digital portion of the board, it must be replaced.

The analog/SCA portion of the board uses a dual operational amplifier and a dual comparator to perform the SCA function. One SCA output is counted in U10, and the other is counted in U5.

Discriminator adjustment is accomplished using a four-channel DAC (U8). The DAC output is set by the SC-755 each time the system is powered up, and whenever a new discriminator setting is entered.

5.3.2. HHV-448:

Refer to "HHV-448 Schematic Diagram" Drawing 10 and "HHV-448 Component Designator" Drawing 11 (Appendix F.).

The HHV-448 high voltage power supply board provides regulated dc high voltage to the voltage signal divider networks (PB-4.7m) which are attached to the photo-multiplier tube on the detector.

5.3.3. GPRB-756:

Refer to "GPRB-756 Schematic Diagram" Drawing 6 and "GPRB-756 Component Designator" Drawing 7 (Appendix F.).

The GPRB-756 accepts the background (low and high), and radiation alarm signals from the SC-755 and switches the appropriate relay contacts. The relay outputs are not used by the SC-755, but may be interfaced to an external system.

5.3.4. DLT-001:

The DLT-001 is a Differential Line Transmitter/receiver to permit noise immune data transfer between the two pillars. The discriminator control signals are transmitted to the slave pillar, and the SCA outputs are received from the slave pillar.

There is also a provision to convert an RS-232 signal to RS-422 compatible levels. The DLT-001 has two DB-9 connectors, one male for DCE equipment, and one female for DTE equipment.

TD, RD, CTS, and RTS signals are converted to differential RS-422 levels. The SC-755 may be connected to the male port, if RS-422 communications are required.

5.3.5. ISR-213A:

Refer to "ISR-213A Schematic Diagram" Drawing 8 and "ISR-213A Component Designator" Drawing 9 (Appendix F.).

The ISR-213A contains an opto-isolator to receive the pulses from an SCA-725. The pulses are transmitted between the controllers in current mode to minimize the impact of noise over the relatively long lines between the two controllers. The opto-isolator outputs are sent to a Schmitt-trigger to sharpen the edges before being sent to the counters on the SC-755 board.

This board also has a voltage inverter to provide VEE (contrast voltage) to the LCD module.

6. MAINTENANCE

Once initial installation has been completed, little maintenance is required. Periodic inspection is recommended to insure proper functioning. This should include (but not be limited to):

- visual inspection for loose wires, etc.
- field calibration
- checking the settings of the control module
- running a variance test
- performing a sensitivity test

It is recommended that a copy of the Performance Verification Checklist (section 6.4.) be filled out whenever the SC-755 is put into service after tuning and recalibration.

6.1. FIELD CALIBRATION PROCEDURES

WARNING:
This procedure involves high voltage and should only be performed by qualified personnel!

Since the calibration procedures require specialized tools and knowledge, only qualified technical personnel should work on these instruments. TSA's technical staff is always ready to answer any questions. The following tools are needed for this procedure:

DVM with a resolution of 0.1 millivolts (.0001 volts)
High voltage probe with a range of 10,000 Vdc and Zin 100 MΩ
Oscilloscope with greater than 20 Meg. band width
5 to 10 μCi ^{137}Cs source

NOTE:
Other mono-energetic sources may be used. Call TSA for full details.

6.1.1. SC-755 Access:

Refer to "SC-755 Internal 3D View" Drawing 3 (Appendix F.).

All of the calibration adjustments are located in the SC-755 enclosure. To gain access for calibration, loosen the four screws located in the corners of the enclosure. The screws are held captive in the lid. Gently pull the lid away from the bottom of the enclosure and swing the lid down to expose the electronics.

The board in the lid is the SC-755 board. This board contains the amplifiers and digital electronics.

The base contains three boards, the GPRB-756, the ISR-213A, and the HHV-448. Refer to "SC-755 Internal 3D View" (Appendix. F Drawing 3) to identify the boards. The only board that requires adjustment is the HHV-448.

The display contrast may change slightly with outside temperature variations. If the display is difficult to read, adjust R2 on the ISR-213A board. Refer to "ISR-213A Component Designator" Drawing 9 (Appendix F.) for component locations.

Do not proceed with calibration until the input voltage has been verified. The input voltage must be between 10 and 16 volts dc.

6.1.2. Calibrating the HHV-448:

Refer to "HHV-448 Schematic Diagram" Drawing 10 and "HHV-448 Component Designator" Drawing 11 (Appendix F.) while following the calibration procedure.

CAUTION:

Do not exceed full scale pulse amplitude of 2 volts peak at TP1/4. Do not exceed the maximum high voltage specification for the detector.

The High Voltage is adjusted using R1 on the HHV-448 board.

This is a general procedure. For special detectors or requirements, please contact TSA's engineering staff for assistance.

Place the test source on the detector that is connected to the channel being calibrated. Attach the oscilloscope to the SC-755 board and set as follows:

Set channel 1 probe to TP1.
Set probe ground to ground.
Set the vertical deflection to .5 volt/division
Set horizontal sweep speed to 0.5 µseconds/division.
Set positive edge triggering

Make adjustments as follows:

Adjust the trigger level and intensity on the oscilloscope for the best display.
Adjust R1 on the board to achieve a peak pulse amplitude of 0.75 ±0.05 volt at TP1
Move the probe to TP4 and verify that the amplitude is approximately 0.75 volt.
If not, adjust the high voltage to achieve 0.75 volt pulse amplitude.

Neither channel should exceed 0.75 volt pulse amplitude. The gain can be adjusted to balance the two channels.

The signal seen should resemble "Typical Pulse Profile" Drawing 12 (Appendix F.).

6.1.3. Calibrating the Amplifier:

Refer to "SC-755 Board Schematic Diagram" Drawing 4 and "SC-755 Board Schematic Designator" Drawing 5 (Appendix F.) for calibrating the amplifier.

CAUTION:

Do not exceed 5 volts peak pulse amplitude at TP5/6.

Follow the steps as outlined below to calibrate the amplifier:

Move the scope probe to TP5
Adjust R1 on the SC-755 board to obtain a 2.0 ±0.1 volts pulse amplitude
Move the probe to TP6
Move the source to the second detector
Adjust R16 for the same pulse amplitude

6.2. VARIANCE ANALYZER MODE

After calibration is complete, a variance test should be performed. The variance analyzer will identify many problems with both the detectors and associated electronics.

In most systems, TSA recommends running five, 15 second passes. After five passes all variance readings should be less than 0.15.

Refer to Appendix C. Formulas for further detail on the variance test and the formulas used. Press the pound (#) key to terminate the variance test.

NOTE:

The variance for a detector that is disabled will be 99.00.

6.3. SENSITIVITY TEST

Due to the many different environments and materials being monitored, the sensitivity test will vary from site to site, although several general principles apply in all cases.

For technical information, contact the TSA Engineering staff.

6.4. PERFORMANCE VERIFICATION CHECKLIST

___ Repairs made (if any): list component and type of repair:

_____

_____

___ System calibration: Unchanged: _____ New Values: _____

Master LLD set to: _____ Slave LLD set to: _____

Master ULD set to: _____ Slave ULD set to: _____

Parameter settings:

Number of Detectors set to: _____ Occupancy hold-in set to: _____

Low Alarm set to: _____ Alarm Comparison Interval set to: _____

High Alarm set to: _____ Sigma set to: _____

Algorithm set to: Sum: _____ Horizontal: _____ Vertical: _____ Single: _____

Background Level (N*Sigma) set to: _____

Background Time set to: _____

___ Electronic calibration: Master Pillar: SC-755 _____ HHV-448: _____

Slave Pillar: SCA-456 _____ HHV-448: _____

___ System starts up and runs initial self-test without errors.

___ All modes operational

___ Background mode in operation area; count = _____

___ Variance test: variance = 1: _____ 2: _____ 3: _____ 4: _____

___ Walk-through test; list sources and sizes used:

_____

_____

Performed by: _____ Date: _____

7. TROUBLESHOOTING

This guide is designed so that on-site personnel can service the SC-755 and effect necessary minor repairs. It covers procedures and parts down to the board level. Any other problems should be referred to factory authorized service personnel. Unauthorized repair voids warranty.

When a problem occurs, it is important to isolate the cause as much as possible. This is accomplished by a step by step procedure which checks each of the assemblies for proper function and works upwards through the system.

Begin with a physical inspection of the unit, then check the input power supply and cabling.. If the physical inspection shows no obvious cause for the problem, proceed by checking the controller assemblies.

After repairs have been made, a field calibration must be performed. Refer to Field Calibration Procedures (section 6.1.).

When repairs are completed and the unit returned to operation, a copy of the Performance Verification Checklist (section 6.4.), should be filled out and filed for future reference.

7.1 CONTROLLER ASSEMBLIES

The individual controller assemblies section of the troubleshooting guide is designed so that on-site personnel can service the SC-755 and effect necessary minor repairs. It covers procedures and parts down to the board level. These procedures require specialized tools and knowledge. Only qualified technical personnel should work on these instruments. Any other problems should be referred to factory authorized service personnel. TSA's technical staff is always ready to answer any questions.

This section deals with the individual assemblies and how to repair them. As stated at the start of this section the steps only go to board level.

Physically inspect the unit for harness wiring or connector problems. This procedure does not cover the replacement of wires or connectors. Such replacement should only be done by qualified service personnel. Questions concerning parts or wire type and availability may be addressed to TSA's Engineering staff.

If a problem is suspected in the SC-755, replace it with a known good assembly, either from spare parts or from another unit. However, remember that the replacement unit will have to be calibrated.

This section will follow the Flow Diagram of a SC-755 as a component of a working portal monitor system as much as possible.

7.1.1 Detector Assemblies:

When the steps call for disconnecting or re-connecting cables, the instrument should be turned off, and when the step is completed, it should be turned back on to check the results of that test.

NOTE:

The signal cable is the one with the BNC connector. The high voltage cable is the one with the MHV connector. The high voltage cable is the larger of the two.

7.1.2. Verify High Voltage:

Using a DVM with a high-voltage probe, verify the high voltage at the MHV connectors on the SC-755.

Disconnect the MHV connectors from both units.
Measure the high voltage from the center conductor (+) to ground (-).
The voltage should be between 600 and 1,500Vdc, and stable within ±5 Vdc.
Record the voltage, and adjust R1 on the HHV- 448 board.
Adjust R1 on the HHV-448 board to at least 50 volts above and 50 volts below the recorded voltage.
This will ensure that the regulator is operating properly.

If this voltage is out of spec, and/or will not adjust over this range, replace the defective HHV- 448 board before continuing with this procedure.

7.1.3. Verify Signal Outputs:

Verify the signal outputs from the detectors using an oscilloscope.

Set the oscilloscope to 50 millivolts/division vertical gain.
Set the time base to 1 millisecond/division.
Set the trigger to negative slope.
Use the existing BNC cable to connect the detector output to the oscilloscope input. (If necessary, the BNC cable may be extended using a BNC to BNC adaptor to connect a second cable.)
The oscilloscope should display negative pulses ranging from 50 to 1,400 millivolts in amplitude.
Repeat this test for all detectors.

NOTE:

If the pulses are not present for any detector, check the trigger level and intensity on the scope.

If the pulses are not present, substitute the voltage divider assembly with a known working assembly, or replace the entire detector assembly.

NOTE:
The system must be recalibrated after any components are replaced.

7.1.4. SC-755 Controller:

The controller's function is to receive the detector signals, which are amplified and discriminated by the analog section and sent to the digital section for counting and processing. The controller provides high voltage to the detector assemblies from the HHV-448 board.

Physically inspect the unit for harness wiring or connector problems. This procedure does not cover the replacement of wires or connectors. Such replacement should only be done by qualified service personnel. Questions concerning parts or wire type and availability may be addressed to TSA Engineering staff.

If a problem is suspected in the SC-755 instrument, replace it with a known good assembly. This can be accomplished by either substituting from spare parts or from another complete unit.

NOTE:
It is important to remember that the replacement instrument will have to be calibrated. Refer to Calibrating the SC-755 (section 6.1.3.).

APPENDIX

A. WARRANTY

STANDARD WARRANTY FOR TSA SYSTEMS INSTRUMENTS

TSA Systems, Ltd., warrants this instrument to be free from defects in workmanship and materials for a period of twelve months from the date of shipment, provided that the equipment has been used in a proper manner and not subjected to abuse. At TSA's option, repairs or replacements will be made on in-warranty instruments without charge at the TSA factory. Warranty of sub-systems made by other manufacturers will be extended to TSA customers only to the extent of the manufacturer's liability to TSA. TSA reserves the right to modify the design of its product without incurring responsibility for modification of previously manufactured units. Since installation conditions are beyond the company's control, TSA does not assume any risks or liabilities associated with methods of installation or with installation results.

Every effort is made to keep the manuals up to date and accurate. However, because TSA Systems is constantly improving and upgrading the product line, TSA can make no guarantee as to the content of current manuals. No obligations are assumed for notice of change or future manufacture of these instruments.

Manufactured by

TSA SYSTEMS, LTD.
14000 MEAD STREET
LONGMONT, COLORADO 80504-9698
970.535.9949
FAX: 970.535.3285

B. GLOSSARY

ADC: Analog to Digital Converter, is an integrated circuit that converts an analog signal into a binary number that can be used by the microprocessor.

CPS or cps: Counts Per Second

High Background Alarm/Fault: The condition that occurs if the counts exceed the programmed high background level. This condition prevents further operation until the problem is corrected. Normally set in cps.

LCD: Liquid Crystal Display

LED: Light Emitting Diode

LLD: The Lower Level Discriminator provides a threshold, usually adjustable, that determines the lowest signal level that will be accepted as a nuclear pulse by the system's electronics. Some systems have both upper and lower level discriminators that can be used to set a discriminator window. The discriminator window can be used to effectively reduce the background counts, and increase system sensitivity to certain isotopes. Also see ULD.

Low Background Alarm/Fault: The condition that occurs if the counts fall below the programmed high background level. This condition prevents further operation until the problem is corrected. Normally set in cps.

POST: Power On Self Test

Rolling Background: This is the background accumulation method used in most of TSA's instruments. Background accumulation is done in ten separate buffers, each buffer represents 1/10 of the total background time. As each buffer is filled, the background is updated. This results in a background update at background time/10. Initial background accumulation requires the full background time.

Standard Background: Standard background requires the full background time for the initial background and updates.

ULD: The Upper Level Discriminator provides a threshold, usually adjustable, that determines the highest signal level that will be accepted as a nuclear pulse by the system's electronics. Also see LLD.

C. FORMULAS

The following formulas are used in various systems manufactured by TSA Systems, Ltd. They are provided to assist in verifying system operation and to give our customers a better understanding of how the systems operate

C.1. ACTIVITY FROM COUNTS

$\text{Activity} = \frac{N}{\text{Eff} * 37}$	Where:	Activity = Activity in nCi
		Eff = Decimal efficiency (i.e. 10% = 0.1.)
		N = Net counts per second (cps – background cps)

C.2. EFFICIENCY

$E = \frac{N}{37 * \text{activity}}$	Where:	N = cps with source – background cps
		activity = test source activity in nCi

C.3. N*SIGMA ALARM LEVEL

This formula calculates the minimum activity, in disintegrations per minute, that can be reliably detected under a given set of operational conditions.

$\text{Alarm Level} = \left(N * \sqrt{\text{bkg}} \right) + \text{bkg}$	Where:	bkg = Background counts
		Sigma = 1bkg
		N = N*Sigma value

C.4. RELIABLE DETECTABLE ACTIVITY (RDA) FORMULA

This formula calculates the minimum activity, in disintegrations per minute, that can be reliably detected under a given set of operational conditions.

$F = \left(\frac{CON + \sqrt{CON^2 + 4\left(FA\sqrt{BKG} + BKG\right)}}{2} \right)^2$	BKG = total background counts per count time
	CON = confidence sigma
	CT = count time in seconds
	E = system efficiency in percent
$G = \frac{F - BKG}{CT}$	F = false alarm level in cps
	FA = false alarm sigma
$RDA = \frac{2200 * G}{37 * E}$	G = intermediate variance
	RDA = reliable detectable activity in DPM

C.5. SIGNAL TO BACKGROUND RATIO

The following formula is helpful is determining the optimum discriminator settings. Always perform a variance test at the final setting of the lower-level discriminator to ensure that system noise is not being introduced into the amplifier stage.

$Q = \frac{S^2}{B}$	Where:	Q = Quality factor
		S = Net signal (count with source - background)
		B = Background count
		B = Background count
Higher values of Q result in better sensitivity		

C.6. VARIANCE

The variance analyzer mode is used to check whether the counts seen by the controller are actually from the proper distribution. If the distribution approaches normal, the resulting number will approach 0. Any significant deviation from the normal distribution will result in a larger number.

The two most common problems resulting in variance failure are light leaks in the detectors, and periodic noise in the electronics. Periodic noise will result in a number of about 1, a light leak will usually result in a number larger than 2. The number displayed during a variance test is the absolute value of the average of a number of these tests, with one test being performed every nn seconds. The data is valid after three iterations of nn seconds. The pass/fail criteria varies from unit to unit and is included in the variance section of the manual on most units.

$\overline{R} = \frac{R}{I}$	Where:	R = the quality factor
		$S^2 = \text{variance} \frac{\sum \left(C - \overline{C} \right)^2}{N - 1}$
		C = each of the individual counts
$R = \frac{S^2 - \overline{C}}{\overline{C}}$		$\overline{C} = \text{the mean of the counts} = \frac{\sum C}{N}$
		N = number of counts taken
		$\overline{R}$ = mean variance
		I = number of iterations

D. CONFIGURATION TRACKING SHEET

TSA MODEL NUMBER:_____ SERIAL NUMBER:_____

SOFTWARE VERSION:_____ DATE RECEIVED:_____

OPTIONS AND ACCESSORIES:_____

_____

SYSTEM MODIFICATIONS

MODIFICATION:_____

_____

INSTALLED BY:_____ DATE:_____

MODIFICATION:_____

_____

INSTALLED BY:_____ DATE:_____

MODIFICATION:_____

_____

INSTALLED BY:_____ DATE:_____

MODIFICATION:_____

_____

INSTALLED BY:_____ DATE:_____

E. PARTS

E.1. RECOMMENDED SPARE PARTS

A complete list of spare parts is available by contacting TSA Systems, Ltd.

E.2. SPARE PARTS ORDERING INFORMATION

To facilitate the processing of spare parts orders the following information is required.

- Product Number
- Product Serial Number
- TSA Stock number
- Part description (from parts list)

When ordering programmed proms, the software version is required. This can be found on the prom label.

NOTE:
Model number suffixes are generally not included in the text of the manual, however, the suffixes in the PARTS LISTS must be included on orders for spare parts.

For Assistance Call:

TSA SYSTEMS, LTD.
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F. DRAWINGS

Please reference the drawings package provided with the instrument to view the following: