



**MULTICHANNEL ANALYZER**  
**MODEL MCA-465**

**OPERATING AND SERVICE MANUAL**

Version 3.00z  
December 20, 2004



**MCA-465**  
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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 handle and care for the MCA-465. Since applications are necessarily site-specific, operation procedures are given in general terms. Service and repair are covered to board or subassembly level. Anything more complex than this requires that the instrument or assembly be returned to TSA.

### 1.2. GENERAL DESCRIPTION

The MCA-465 provides a full featured 256 channel MCA in a portable, battery powered package. The MCA-465 can be fitted with an internal Sodium-Iodide crystal or used with a variety of external probes.

The MCA-465 has a back lit 256 x 128 pixel liquid crystal display for viewing the spectral data graphically, or parametric information during set up and calibration. User interface is provided via eight membrane switches on the front panel of the instrument. These switches provide operator access to all functions of the MCA-465 through a series of menus.

A movable on screen cursor provides the channel number and count data for the selected channel under the graphics display.

Access to the set up mode is controlled by an internal dip switch setting. This allows the customer to control whether the operator can access the set up mode or only collect data.

A "FIELD CALIBRATION" may be accessed from the set-up menu. This allows fine tuning the gain from the front panel of the instrument. The field calibration requires the use of an external source, and allows the operator to place the energy peak in precisely the desired channel. The calibration data for the internal detector is stored in the MCA- 465's battery backed ram. The calibration data for external probes is stored in non-volatile memory in the probe(s) and read by the MCA-465 on power up.

The MCA-465 provides both real time and live time modes of operation. The instrument may be programmed to auto-scale, wrap around, or "flat top" the vertical display.

The MCA-465 provides four user programmable Regions of Interest. The ROIs are set using the graphics display with the channel numbers displayed below the spectrum.

A communications package is available to allow set up and downloading data using an IBM PC. This package allows scans to be downloaded from the MCA to the PC using an RS-232 communications port. The data may selectively be viewed graphically, written to disk with embedded comment line, or written to disk in ASCII format for post-processing. The parameters may also be set from the PC by entering the data directly from the PC's keyboard.

Up to fourteen scans may be stored internally. These scans are identified as background, scan or CMP data by the operator and automatically date and time stamped. The scans may be recalled for viewing on the MCA or downloaded to a PC using the communications link.

### 1.3. CONTROLS AND INDICATORS

The front panel of the MCA-465 houses the display and the membrane switches required for operation. Normally the display will present the spectral information from the most recent scan with four lines of text information indicating the mode of operation, and current status of the instrument.

The power on/off and backlight switches are positioned on either side of the display, while the switches that control system operation and cursor movement are located below the display window.

A menu of the lower switch functions is displayed in the bottom row of the graphics display as the individual functions are available. The cursor movement switches automatically repeat when held down.

#### 1.4. SAFETY PRECAUTIONS

Cautions and warnings related to specific procedures are cited in the appropriate places in this manual. Some general precautions are:

##### WARNINGS:

*The MCA uses high voltage during operation. Care must be taken during service procedures. Service should only be performed by qualified technical personnel.*

##### CAUTIONS:

*As with any sensitive electronic instrument, the MCA-465 should not be dropped or subjected to severe mechanical shock.*

*The front panel switches are pressure sensitive membrane switches. Avoid using sharp objects to activate the switches.*

## 1.5. SPECIFICATIONS

Detector:	One, optional, internal: 1" diameter x 2" (2.5 x 5cm) NaI(Tl) crystal
Display:	2.5"h x 4.8"w (6 x 12.2 cm) graphics display, 128 x 256 pixel, w/backlight
Communication:	RS-232C interface (9600 baud)
Data Storage:	14 spectra can be stored in internal battery backed RAM; 14 CMP mode verification measurements may be stored
Power:	Internal: Two sealed, lead-acid battery packs, 6 volts @ 4.0 Ampere hours per pack. The universal input battery charger will recharge the batteries from a 90 - 250 volt, 47 - 63 hertz source in 16 hours.
Battery life:	More than 12 hours of normal operation on a full charge
Scan Time:	1 to 9999 seconds.
Serviceability:	Unit can be serviced to the subassembly level in the field
Dimensions:	6.2"h x 4.8"w x 4.9"d (15.8 x 24 x 12.5cm)
Weight:	≈7.5 pounds (3.4kg)
Environmental:	
Temperature:	32° to 120°F (0° to 50°C)
Humidity:	Up to 95% non-condensing

## 2. INSPECTION AND SETUP

The following procedures should allow on-site personnel to correctly install and set up the MCA-465 for normal operation. Follow the procedures in the order given. It is recommended that a copy of the Configuration Tracking Sheet (Appendix D.) be filled out after initial installation and whenever the MCA-465 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.

### 3. OPERATING INSTRUCTIONS

#### 3.1. GENERAL OVERVIEW

The MCA-465 can display bar or line graphs of the multi-channel data, as well as perform integrations on regions of interest to look for specific isotopes. The multi-channel analyzer has 254 usable channels (the data in channels 0 and 255 are not displayed).

The instrument is controlled by eight membrane switches located below the display on the front panel. These switches control set-up and operation of the instrument either directly or using a menu system where required. The switches are labeled with the appropriate function names.

A brief description is given below.

<b>GENERAL MENU FUNCTIONS</b>	
Mode	Presents a menu of available operating modes.
Start/Stop	Toggles Start/Stop of acquisition.
Store	Presents a menu of options for storing data and viewing or erasing stored data
Enter	Accepts the current selection in some menus
↑ (Inc)	Moves the cursor up in the current menu, or increments the value at the current cursor position
↓ (Dec)	Moves the cursor down in the current menu, or decrements the value at the current cursor position
← (Left Arrow)	Moves the cursor left or decrements the value at the current cursor position in time and date set mode
→ (Right Arrow)	Moves the cursor right or increments the value at the current cursor position in time and date set mode (also selects menu options)

### 3.2. OPERATING MODES

The following table represents the menu of Operating Modes available with brief descriptions of each. Refer to the appropriate section for detailed information.

<b>OPERATING MODES</b>	
<b>Mode</b>	<b>Brief Description</b>
Power-Up / Self Test	(3.3.) automatically executes a number of self-tests
Set-up Mode	(3.4.) presents menus for ROI, parameters, graphics, calibration
MCA Mode	(3.5.) records specified data from its 254 usable channels
ROI Mode	(3.6.) allows operator to program 4 ROI by channel number
CMP Mode	(3.7.) allows operator to confirm specific isotope presence
Count/Find (HHD)	(3.8.) performs search/find features
Storing Data	(3.9.) allows data storage according in user defined areas

The operating modes are explained in detail on the following pages.

### 3.3. POWER-UP AND SELF-TEST

When the unit is turned on, the instrument will automatically execute a number of self-tests that require several seconds to complete.

The possible errors that can occur during the power-up self-test sequence are:

1) Failed RAM Test:

The random access memory on the MCD-467 board is not working properly.

The computer board should be repaired or replaced.

2) Parameters Lost:

The parameters have changed since they were last modified from the set-up menu. The MCA must be recalibrated. If this problem persists there is a problem with the battery-backed memory that stores the parameters.

3) Battery Failure:

The battery needs to be recharged or replaced.

After the power up tests, the MCA will present the operating screen and is ready to set up or operate.

### 3.4. SET-UP MODE

NOTE:

*The internal set-up mode may be accessed only if dip switch 1 position 1 on the MCD-468 board is in the "open (off)" position.*

If the operator does not require access to the set-up mode, the set-up mode may be disabled by setting DIP switch 1 on the MCD-467 board to the "CLOSED (ON)" position. With the switch "OFF", the set-up mode may be accessed from the main menu.

The MCA-465 may be set up using the front panel switches, or with an IBM PC or compatible personal computer using the MCA-465 communications program.

To enter the SET-UP MODE from the front panel, press the MODE switch. This will present the "Mode Menu":

<b>MODE MENU</b>
_MCA mode
ROI Verify Mode
CMP mode
HHD mode
Set-up mode
Run

Use the ↑ (INC) and ↓ (DEC) switches to move the cursor to the desired option and the → switch to accept the current selection. This holds true throughout the MCA-465's menus.

In some cases the "ENTER" switch is used to accept an entry. These cases are noted in the appropriate section in this manual. The last line in most menus is an "exit" mode. Selecting this option will exit to the previous menu.

#### 3.4.1. Set-Up Mode:

Move the cursor to the "Set-up mode" line using the up/down arrow switches, and press the "→" switch to select the current line. This will present the "SET-UP MENU". Move the cursor to the desired function and press the "→" switch to select the current line.

<b>Set-Up Menu</b>	
(3.4.1.1.)	_ ROI mode
(3.4.1.2.)	Parameters
(3.4.1.3.)	Graphics
(3.4.1.4.)	Calibrate
(3.4.1.5.)	Exit set-up

The "SET-UP MENU" offers the following options:

##### 3.4.1.1. ROI Mode:

The up/down arrows select the ROI # (Region of Interest). The MODE switch toggles between Lower and Upper ROI limits. The limits are changed with left/right arrows, the highlighted channel number will change, and the cursor will move to reflect the current area on the screen.

Press the "ENTER" switch to accept the values and exit the ROI set-up menu.

3.4.1.2. Parameters:

Parameters		
(3.4.1.2.1)	_TIME	HH:MM:SS MM/DD/YY
(3.4.1.2.2)	Live Time	NNNN
(3.4.1.2.3)	Real Time	NNNN
(3.4.1.2.4)	Time Mode	Real
(3.4.1.2.5)	Graph type	Bar graph
Return to previous menu		

The set-up menu presents the operator with a choice of parameters. These parameters include setting time features and graph types.

The parameters are described in detail below.

Set the following parameters.

3.4.1.2.1 Time:

The time parameter is simply entered in the instrument using digits to confirm the hour, minute and second count for the present month, day and year.

To adjust or change the time and date information, follow the instructions below:

Time and Date		
_HOUR		HH
Minute		MM
Second		SS
Month		MM
Date		Date
Year		YY
Return to previous menu		

Use the up / down arrows to select the desired line in the menu.

Use the left / right arrows to increase or decrease the desired value.

When the settings are satisfactory, move to the bottom line and press the right arrow switch.

This will enable you to return to the "Set Parameters Menu".

3.4.1.2.2. Live Time:

Live time compensates for the pulses that are not processed during "dead time". Press the right arrow switch to move to the time digits, use the up/down arrow switches to increment/decrement the value. Repeat for each digit, when the value is satisfactory, press the "ENTER" switch to accept the value and move the cursor back to the first column of the display.

3.4.1.2.3. Real Time:

Real time collects data for the specified time. Press the right arrow switch to move to the time digits, use the up/down arrow switches to increment/decrement the value. Repeat for each digit, when the value is satisfactory, press the "ENTER" switch to accept the value and move the cursor back to the first column of the display.

3.4.1.2.4. Time Mode:

Move to the time mode line and press the right arrow switch to select either Real Time or Live Time.

Real Time:

Real Time collects data for the specified time.

Live Time:

Live Time compensates for the pulses that are not processed during "dead time".

Dead Time:

Dead time is the time required for analog to digital conversion and processing the data after conversion. This is accomplished by counting each pulse that is detected, and collecting data until the correct number of pulses have been converted and processed.

#### 3.4.1.2.5. Graph Type:

Move to the graph type line, and press the right arrow switch to select either bar graph or line graph.

The parameters that are displayed when the "Set Parameters Menu" is exited will be stored in memory.

#### 3.4.1.3. Graphics:

The "Spectrum Overflow Display" mode offers the following options:

##### Wrap Around To Bottom:

The vertical scale must be set manually. When a channel overflows the graphics screen, that channel will wrap around and begin counting from the bottom of the screen again. The vertical scale must be adjusted using the increase/decrease switches to set the desired vertical scale.

##### No Wrap Around:

The vertical scale must be set manually. When a channel overflows the graphics screen, that channel will remain at the top of the screen. This mode will produce a "flat-topping" of the display until the vertical scale is manually adjusted to permit proper display of the spectrum.

##### Auto Increase Vertical Scale:

The vertical scale will automatically adjust to keep the peak channel within the range of the graphics display. When a new scan is started, the scale will automatically revert to maximum sensitivity (1 count per pixel) and increase as required to keep the spectrum on screen.

#### 3.4.1.4. Calibrate:

Prior to entering the calibration mode move the cursor to the desired channel on the MCA screen (i.e.: channel 83 to calibrate using  $^{137}\text{Cs}$  with the internal detector). Place a calibration source near the bottom center of the MCA (below the TSA logo with the unit sitting on a table).

Determine which channel the test source should appear in. The proper channel for other sources may be determined by dividing the isotope's energy level by 8 keV.

Select "Calibrate" from the SET-UP MENU.

The MCA will begin scanning.

Adjust the calibration using the left/right arrow switches to move the peak directly under the cursor.

The peak will move one channel in the direction of the arrow each time the switch is pressed.

Restart the scan.

Repeat the procedure until the peak is located in the correct channel.

When the result is satisfactory, press the "ENTER" switch to accept the current calibration factor. The calibration factor may be adjusted from 225 to 250; pressing the "STORE" switch during calibration will set the calibration factor at 240.

#### NOTE:

*If proper calibration cannot be achieved using the front panel, the instrument requires a hardware calibration or repair. Refer to Calibration Checklist (section 6.5.).*

#### 3.4.1.4.1. Background Subtract:

In the Background Subtract mode the most recently stored background data is graphically subtracted from the displayed scan. When this mode is enabled, a "B" is displayed at the right side of the top line of text. The same data may be viewed with and without Background Subtract by toggling the mode on and off.

#### 3.4.1.4.2. Peak Strip:

The Peak Strip mode is used in conjunction with ROI Verify to analyze the peaks in a given ROI. When this mode is enabled, a "P" is displayed at the right side of the top line of text. Peak strip first calculates the average of the counts in the ROI boundaries and the channel above and below the boundaries.

The MCA then calculates a line connecting the two points. The integral of the ROI in Peak Strip mode includes only the counts that are above this line (if the integral of the ROI is negative, zero is displayed).

#### 3.4.1.5. Exit Set-Up Menu:

Use the ↑ (Inc) and ↓ (Dec) switches to move the cursor to the exit set-up menu option and the → (Right Arrow) switch to accept the current selection. Selecting this option will exit to the previous menu.

### 3.5. MCA MODE

As a multi-channel analyzer, the MCA-465 records data from its 254 usable channels. This data may be displayed as a line graph or bar graph (user selectable). A movable cursor, presented as a vertical line in reverse video, is provided with a display of the channel number currently indicated by the cursor and the number of counts in the cursor channel. There are 14 data storage areas available to store scans for future retrieval either on the MCA-465 or using an IBM-PC compatible computer equipped with an RS-232 port.

### 3.6. ROI MODE

The ROI (Region of Interest) mode allows the operator to program 4 Regions of Interest by channel number. This is done by entering the SET-UP MENU and selecting the ROI set-up option.

Once the regions have been defined, enter the MODE MENU and select the ROI Verify Mode. This will display the total counts that fall within each ROI.

### 3.7. CMP MODE

This option allows the operator to confirm the presence of specific isotopes in one or more of the four available regions of interest in the instrument.

#### NOTE:

*The default ROIs are based on a calibration of 5 keV/channel. The detector must be calibrated with  $^{137}\text{Cs}$  in channel 132 to achieve 5 keV/channel or the ROIs must be changed to reflect a different calibration. If the gain adjustment does not have enough range for this calibration, raise the high voltage by 50 volts.*

Refer to the calibration procedure for the MCA-465 (section 3.4.1.4.) or external probe for calibration instructions.

The ROI ranges must be set before CMP measurements are attempted.

CMP operation is selected from the mode menu, move the cursor to CMP mode line and press the right arrow switch to enable CMP measurements.

The instrument will prompt the operator to position the probe for background measurement and press the "START" switch. When the "START" switch is pressed, the instrument will begin a background scan. When the background scan is complete, the operator will be prompted to position the probe for a measurement scan and press "START". When the measurement scan is complete, the instrument will display the current measurement spectrum as well as activity status NC (not confirmed) or Y (confirmed) for each ROI.

Determining the correct detector positions for background and measurement scans are site specific, and must be determined by the end user.

To store the spectrum, press the "STORE" switch then select store data from the menu. The background and the measurement spectrums will both be stored in the next available data area. Only the measurement spectrum may be recalled for viewing on the MCA- 465, but both spectrums may be viewed simultaneously using the PC communications package.

To initiate another CMP scan, press the "ENTER" switch.

To exit the CMP mode, press "ENTER", then the mode switch and select another mode of operation.

Pressing the START/STOP switch during a scan aborts the current scan and returns to the CMP opening screen.

When the MCA-465 is shipped from the factory, the ROIs are preset for Americium, Plutonium, HEU, and DU. These labels will correspond to ROI 1 through 4 respectively. The ROIs are user settable, but the labels are not.

In the CMP mode, the MCA-465 peak strips the compton scatter from the ROIs in both the background and the measurement scans.

After peak stripping the ROI must contain a minimum of 20 counts to allow CMP operation. If the integral of the ROI is  $<20$  the CMP will always indicate Not Confirmed (NC).

The instrument then checks to see if the integral of the measurement scan is 3 sigma greater than the integral of the background scan. Each ROI that meets the 20 count minimum and the 3 sigma above background test will display a "Y" in the CMP screen.

All other ROIs will display "NC" for not confirmed. A "Not Confirmed" indication does not necessarily indicate a total absence of the isotope, only that there is inadequate activity in the ROI to pass the CMP test criteria.

### 3.8. COUNT/FIND (HHD MODE)

The HHD (Hand-Held Detector) mode performs search/find features similar to TSA's HHD-440 instrument. Upon entering the HHD mode, the instrument will acquire a 20 second background. When the background is complete, it will be displayed in cps.

Press the START/STOP switch to start the search/find operation. Pressing the START/STOP switch again will return to background mode.

The current background is automatically set to  $\frac{1}{2}$  scale on a bar graph display, the second line shows the current background in cps, and the third line of the display will read either "Count" for search mode, or "Find" for find mode plus the current count in cps. The "ENTER" switch toggles between Count and Find modes.

The "Count" mode will sound the speaker at background plus 4 sigma. This mode is intended to quickly scan an area, item, or person for radioactivity.

The "Find" mode is intended to help locate a source after it is detected. The find mode sounds the speaker at background plus one sigma, and increases the frequency of the tone each additional sigma above background until the tone becomes continuous.

### 3.9. STORING MULTI-CHANNEL DATA

The MCA-465 has a provision for storing multi-channel scans for later retrieval. There are 14 data storage areas, each of which can store a scan, a background, or the background and measurement data from a CMP scan.

Scans may be recalled directly on the display, or may be downloaded to a computer via the RS-232 link. The computer communication link is discussed at length later in this manual. (4. PC Communications)

This storage menu is accessed by pressing the "STORE" switch while in either the MCA or ROI Verify operating screens.

<b>STORE MCA DATA</b>	
(3.9.1.)	_Store data
(3.9.2.)	Store background
(3.9.3.)	View stored data
(3.9.4.)	Erase stored data
(3.9.5.)	Erase all data
(3.9.6.)	Lock a data area
(3.9.7.)	Exit store data

#### 3.9.1. Store Data:

This will store the current scan in the next available storage area, and ask you to press any key to continue.

If all storage areas are full, the instrument will display a message that must be acknowledged by the operator before resuming operation.

### 3.9.2. Store Background:

This will store the current scan as background data in the next available storage area, and ask you to press any key to continue.

If all storage areas are full, the instrument will display a message that must be acknowledged by the operator before resuming operation.

### 3.9.3. View Stored Data:

This will display a directory of the data areas and allow you to select which one you wish to view.

<b>Data Area Directory</b>
Data Area Number
Date of the Scan
Time of the Scan
Scan, Background, or CMP Flag
Open or Locked

Each data area will occupy one line of the screen presenting the following information.

Move the cursor to the area to be viewed, and press the right arrow switch to view the area. After viewing the area, press the "ENTER" switch to return to the Directory.

Select another area to view, or Exit to return to the Store MCA data menu.

### 3.9.4. Erase Stored Data:

This option allows data areas that have not been locked to be erased. This option will present the Directory of data areas. Move the cursor to the area you want to erase and press the right arrow to erase the data area.

If the data area is locked, the command will be ignored.

#### WARNING:

*Use the erase options carefully; there is no way to recover the data once it has been erased.*

#### 3.9.5. Erase All Data:

This option erases all data areas whether they are locked or not.

#### WARNING:

*Use the erase options carefully; there is no way to recover the data once it has been erased.*

#### 3.9.6. Lock a Data Area:

This option will present the Directory of data areas. Move the cursor to the area you want to lock and press the right arrow to lock the data area. Once a data area is locked, it may only be unlocked using the PC communications package, or erased using the Erase All Data areas option.

#### 3.9.7. Exit Store Data:

To exit the store data mode, use the ↑ (Inc) and ↓ (Dec) switches to move the cursor to the exit store data option and the → (Right Arrow) switch to accept the current selection. Selecting this option will exit to the previous menu.

#### 4. PC COMMUNICATIONS

The MCA-465 instrument functions with a PC Communications program and is identified as version 5.12. The PC communications program is supplied on a 3 1/2" disk (a 5 1/4" disk may be requested) and will run on most IBM PC/compatible computers.

Make a copy of the program disk or copy it onto the hard drive and store the master copy in a safe place.

Using this program you may execute the following tasks:

- View/change MCA parameters
- Change modes
- Download stored data areas
- Unlock stored data areas
- Erase stored data areas
- Set date and time from the PC's internal clock
- View stored data areas on the PC's screen
- Program external probes
- Determine the MCA-465 software version
- Control the MCA-465

#### 4.1. MAIN PROGRAM MENU

To execute the program on a color monitor type "MCACOM" at the DOS prompt. On a monochrome monitor, type "MCACOM/M". This will present the main program menu:

MAIN PROGRAM MENU	
(4.1.1.)	MCA Parameters
(4.1.2.)	MCA Modes
(4.1.3.)	Download Data
(4.1.4.)	Unlock Data Areas
(4.1.5.)	Erase Stored Data
(4.1.6.)	Set Date and Time
(4.1.7.)	View Data
(4.1.8.)	Convert Data
(4.1.9.)	Calibrate MCA
(4.1.10.)	Version
(4.1.11.)	Control
(4.1.12.)	Program External Probe
Quit	

With a few exceptions these functions are very similar to those available from the front panel switches.

Please refer to the descriptions in the Operating Instructions (section 3.) for detailed information on the menu options. In the areas that differ, complete information will be given.

Use the ↑ (Inc) and ↓ (Dec) switches to move the cursor to scroll the highlighted bar through the menu and to the desired option. Use the → (Right Arrow) switch to accept the current selection. Each selection will present a brief description of the current function.

##### 4.1.1. MCA Parameters:

The MCA parameters menu function presents a list of the following available parameters:

PARAMETERS
ROI (Regions of Interest)
Real Time Values
Live Time Values

Use the cursor switches to scroll through the list. To change one of the parameters in the menu, type in the new value. When you are satisfied with all of the values, press the ESC (escape) switch. You will be given the option of writing the modified parameters to the MCA or returning to

the main menu without altering the previous settings.

#### 4.1.2. MCA Modes:

The MCA mode menu function presents a list of the available modes:

<b>MCA MODES</b>
Display
Time
Graphics
Graph Type

Each mode allows selection and specification of the various options available. Scroll through the list(s) and make the desired selections.

The selections will be stored in the MCA when exit is selected in the VIEW/EDIT MODES menu.

#### 4.1.3. Download Data:

When a CMP data area is down loaded or viewed on the PC, both the background data and the measurement data is downloaded or viewed. The CMP files are identified by a "CMP" in the data type column, as opposed to Bkg or Scan.

##### 4.1.3.1. Download Selected Data

The download selected data menu function allows individual areas to be stored on disk in the host PC. A directory of data areas will be presented. The operator must select the desired data area by scrolling the highlighted bar to the preferred data area and pressing "ENTER". The operator will then be prompted for a file name. The file will be written to the default directory unless the full DOS path is provided.

Repeat the above procedure until all desired data areas are downloaded.

##### 4.1.3.2. Download All Areas:

The download all data areas menu function allows all areas to be downloaded and stored on disk in the host PC. The operator will be prompted for a file name, and all data areas will be downloaded into this file.

When the file is viewed, data area 1 will be displayed first. Use the "Page Up" and "Page Down" keys to display other data areas.

#### 4.1.4. Unlock Data Areas:

The unlock data areas menu function locks or unlocks all or selected data areas.

The unlock data areas function will present a directory of the data areas. The operator must scroll the highlighted bar to the desired area and press "ENTER" in order to lock or unlock that specific area. Repeat the procedure until all of the desired data areas are locked or unlocked.

The unlock data areas menu function can lock or unlock all data areas. This function performs the selected operation on all the files stored in the MCA.

#### 4.1.5. Erase Stored Data:

The erase stored data function erases all or selected data areas.

Erase selected areas will present a directory of the data areas, the operator must scroll the highlighted bar to the desired area and press "ENTER". The data area will be erased.

Repeat the procedure until all of the desired data areas are erased.

#### WARNING:

*Use the erase options carefully. There is no way to recover the data once it has been erased.*

#### 4.1.6. Set Date and Time:

The set date and time menu function writes the date and time from the host PC's internal clock/calendar to the MCA.

#### 4.1.7. View Data:

The view data menu function allows MCA data to be viewed on the host PC's graphic screen. This option will allow the operator to optionally view an MCA data area or a previously stored MCA data file on the host PC's graphic screen.

To view a data area:

If an MCA data area is selected, the MCA's data directory will be displayed, and the operator may scroll through the list until the desired area is highlighted. Press "ENTER" to view the data.

To view a data file:

The PC's file name, including its path (if it is not in the default directory), must be supplied. Three lines of data will be displayed above the spectrum.

Line 1 gives the file name or data area and the scale factor.

Line 2 gives the date and time that the data was originally stored in the MCA.

Line 3 gives the actual acquisition time for the scan.

This time will reflect operator termination and/or live time correction.

Regions of Interest (ROIs):

The ROIs associated with a scan are downloaded to the PC and identified on the PC screen. The ROIs may be changed on the PC's screen, but the changes are not stored with the scan.

To view a ROI:

Press the F9 key to view the ROIs associated with a scan. This will enable the ROI display in the active window. The ROI display shows the ROI limits and the integral of the counts in the ROI. Press the Delete key to turn the ROI display off again.

The ROIs (Regions of Interest) are color coded as follows:

Regions of Interest		
ROI 1		Red
ROI 2		Green
ROI 3		Light Blue
ROI 4		Violet

Pressing the F10 key toggles the active window between measurement and background scans.

To change the ROIs, move the cursor to the desired channel and press the function key for the ROI's lower limit, then move the cursor to the desired channel, and press the

function key to set the upper limit of the same ROI.

To change the ROIs (Regions of Interest) on the PC viewer:

Change the ROIs		
F1		changes ROI 1 low
F2		changes ROI 1 high
F3		changes ROI 2 low
F4		changes ROI 2 high
F5		changes ROI 3 low
F6		changes ROI 3 high
F7		changes ROI 4 low
F8		changes ROI 4 high

The left/right arrow keys move the cursor down and up one channel at a time in the selected window.

Holding the <Ctrl> key and pressing the arrow keys moves the cursor 5 channels at a time.

The channel number and counts in that channel are displayed below the window.

#### 4.1.8. Convert Data:

This menu function allows the operator to convert binary files that have been downloaded from the MCA to either printer (file name.PRN) or ASCII (file name.ASC) format files. The operator must enter a file name for the converted files. The system will append the appropriate extension.

#### NOTE:

*The data in channels 0 and 255 is not displayed, but will be present in the converted data files.*

When CMP scan data is converted, the background data is stored in the next available data area and the scan data is stored 14 areas above the background.

For example:

A CMP background is stored in area 3. The associated scan data will be stored in area 17. The areas above 14 are not accessible directly. They are strictly reserved for CMP data.

The printer file will prompt the operator for a comment (40 characters max) that will be stored with the data. The data is written to disk as an ASCII text file of eight columns by 32 rows with each entry representing the number of counts in the corresponding channel.

Each data area is terminated with a form feed.

A sample file might look something like the chart on the following page.

TSA Systems Ltd. MCA-465

Scan date: 01/31/93 time: 15:33:12

Data Area: 1

Scan time: 10 Acquire time: 10

Comment: SAMPLE PRINTER FILE

Chan:	0	1	2	3	4	5	6	7
0:	1	0	1	0	0	0	0	0
8:	1	0	0	0	2	1	0	0
16:	0	1	0	0	0	0	0	0
24:	2	0	1	0	1	0	0	1
32:	0	0	0	2	0	1	2	2
40:	0	0	2	0	1	1	1	2
48:	1	2	2	0	0	0	0	1
56:	2	1	2	4	1	3	4	2
64:	2	2	2	2	0	2	2	2
72:	2	0	2	1	2	1	4	2
80:	3	2	1	1	5	2	4	5
88:	3	1	3	3	8	2	2	6
96:	4	3	3	5	1	2	3	2
104:	3	1	3	5	5	4	2	5
112:	7	3	6	8	4	8	7	4
120:	2	4	6	6	6	5	2	5
128:	6	2	5	6	2	7	2	2
136:	4	2	3	2	3	1	6	7
144:	8	6	7	4	3	5	4	4
152:	4	2	2	3	3	4	3	2
160:	8	3	5	2	3	3	1	2
168:	5	3	4	4	2	2	2	4
176:	5	5	3	2	4	5	6	3
184:	6	4	5	4	2	2	4	4
192:	1	1	2	3	1	4	7	5
200:	4	2	6	2	2	1	3	2
208:	1	0	2	4	2	4	3	1
216:	1	2	7	4	3	3	0	1
224:	4	3	2	2	5	6	2	0
232:	4	3	1	0	2	2	4	2
240:	2	3	1	5	2	1	4	2
248:	3	2	2	2	3	0	1	363

The ASCII file will be stored as a single column of 256 ASCII integers, and is suitable for importing into a spreadsheet or other program for plotting or post processing.

When a conversion on a file containing more than one data area will print, the data area number will print at the beginning of each data block.

A sample file is shown to the right:

#### 4.1.9. Calibrate the MCA:

The main menu function feature identified as "calibrate" is not implemented at this time.

#### 4.1.10. Version:

The version function reports the version of software from the MCA-465 (i.e.: Version 2.20).

<b>Multiple Data Area Print</b>	
<b>Area #1</b>	<b>Area #2</b>
1	20
0	0
0	0
1	0
2	1
.	.
The data for channels 5 through 250 has not been printed in these examples.	
.	.
2	1
3	7
0	10
1	11
363	21

## 4.1.11. Control

The control function permits rudimentary control of the MCA-465 from the PC's keyboard. This portion of the program was written as a development tool. It was not intended to allow complete remote control of the instrument.

These functions mimic the front panel switches. The MCA-465 does not return any status to the PC, so the MCA's display must be visible to the operator while using PC control.

Selecting this menu function will present an MCA Control Menu as shown below:

<b>MCA CONTROL MENU</b>	
Mode	Presents a menu of available operating modes.
Start/Stop	Toggles Start/Stop of acquisition.
Store	Presents a menu of options for storing data and viewing or erasing stored data
Enter	Accepts the current selection in some menus
↑ (Inc)	Moves the cursor up in the current menu, or increments the value at the current cursor position
↓ (Dec)	Moves the cursor down in the current menu, or decrements the value at the current cursor position
← (Left Arrow)	Moves the cursor left or decrements the value at the current cursor position in time and date set mode
→ (Right Arrow)	Moves the cursor right or increments the value at the current cursor position in time and date set mode (also selects menu options)
Quit	

#### 4.1.12. Program External Probe:

The program external probe function writes an identifying code to an external probe.

This is normally done by TSA before the probe is shipped, and should only be required in the field if the EEPROM in the probe has been replaced.

The following probe types are supported:

NaI

FIDLER

Plastic

Other with spectral data

Select the probe type by scrolling the highlighted menu bar to the desired type and press the "ENTER" switch.

Verify that the code has been sent properly by exiting the MCA communications program and power cycling the MCA.

Immediately after the sign-on screen, the MCA will acknowledge that an external probe is attached.

## 5. THEORY OF OPERATION

The MCA-465 provides a full featured, multi-channel analyzer in a portable, battery powered package. The 256 channel MCA-465 can be supplied with an internal NaI(Tl) detector, or used with a variety of external probes. Peak strip, background subtract and search/find features are included.

### 5.1. MCD-467 BOARD OPERATION

Refer to "MCD-467 Schematic Diagram #1 of 2" Drawing 9, "MCD-467 Schematic Diagram #2 of 2" Drawing 10 and "MCD-467 Component Designator" Drawing 11 (Appendix F.) for the MCD-467 Digital Circuit Card Assembly.

The MCD-467 board contains the following features:

- Z-80 CPU
- peripheral ICs for the microcomputer
- external probe interface
- Analog to Digital converter
- membrane switch decoders
- LCD driver
- audio circuit

The CPU is based on a Z-80 family microprocessor (U1) with 32 kBytes of EPROM (U6) and 32 kBytes of non-volatile, static RAM (U8).

U8 also has an internal clock/calendar and a lithium battery to maintain time, stored scans, and parameters when the unit is turned off.

RS-232 communications are provided by U2 (KIO) and level shifted by U9.

U5 counts each nuclear pulse, this count is then compared to the MCA spectrum count and used to calculate live-time correction.

U11 is the Analog to Digital converter that performs the amplitude measurements for the MCA spectrum.

U7 decodes the eight front panel function switches that are located below the LCD.

U20 provides pull-up resistors and a de-bounce circuit for the power and backlight switches. These signals are sent to the MCA-468 board where the actual functions are implemented.

## 5.2. MCA-468 BOARD OPERATION

Refer to "MCA-468 Schematic Diagram #1 of 3" Drawing 5, "MCA-468 Schematic Diagram #2 of 3" Drawing 6, "MCA-468 Schematic Diagram #3 of 3" Drawing 7 and "MCA-468 Component Designator" Drawing 8 (Appendix F.) for the MCA-468 Digital Analog Circuit Card Assembly.

The MCA 468 board contains the following features:

- power on/off circuitry
- low voltage power supply
- high voltage power supply
- nuclear pulse amplifiers
- peak detector
- low battery comparator
- Digital to Analog converter

#### 5.2.1. Nuclear Pulse Circuits:

U1 and U2 are the nuclear pulse amplifiers.

#### 5.2.2. Analog Switch:

U3 is an analog switch that allows selection of the input signal from either the internal or an external detector. It also provides input to U8 for the "pulse" signal that is sent to the counter on the MCD-467 board for live time correction.

#### 5.2.3. Peak Detect and Hold:

U5, U6, and Q1 provide the peak detect and hold function. The amplified analog pulse is input to U5. CR7 provides a path to charge the hold capacitor (C19) to the peak pulse amplitude. U6 buffers this signal and provides the reference voltage to the DAC (U7).

#### 5.2.4. The DAC:

The DAC is used as a digital attenuator. When the field calibration is performed, the digital board writes a calibration byte to the DAC. When the calibration process is complete, this byte of data is stored in non-volatile memory, and written to the DAC each time the unit is powered up.

A similar process is used for external probes, except that the calibration data is written to EEPROM in the external probe.

The DAC's output is buffered by U9 and sent to the analog to digital converter on the digital board.

After the analog to digital conversion is complete, the digital board sends the discharge signal to the gate of Q1, which discharges C19 and the unit is ready to process another pulse.

#### 5.2.5. Low Voltage Power Supply:

A "power pulse" is generated on the digital board when the front panel on/off switch is pressed. This pulse clocks U11 and toggle the Q and Q\* outputs. These signals are input to U12 which provides the drive to power relay (K1).

K1 is a self-latching relay. It requires a short pulse to open or close the contacts and maintains that state without power until another pulse is received.

The power relay supplies battery voltage to the switching regulator (U13) and the linear regulator (VR2) for the backlight inverter (BLI1). The 5 Vdc for the logic is provided by linear regulator VR1. VR1 may be powered directly by switched battery or from the +15 Vdc from the switching regulator, depending on the configuration of the MCA-465.

#### 5.2.6. High Voltage Power Supply:

U15 is an astable multivibrator that provides a square wave input to Q4 and Q5. Q4 and Q5 drive the primary of T2. The secondary of T2 is fed to the voltage multiplier (CR11 through CR20 and C44 through C52) and filtered by the RC network on the output.

U16 samples the high voltage output and applies a correction signal to VR3 for high voltage regulation. Q1 and Q2 switch the internal high voltage power supply off when an external detector is being used.

#### 5.2.7. Low Battery Warning:

U14 monitors the battery voltage and provides a low battery signal to the digital board when the batteries are discharged to 10.5 Vdc.

#### 5.2.8. Graphics / Alpha-Numeric LCD:

The liquid crystal display is 256 pixels wide by 128 pixels high and is equipped with an integral electro-luminescent back light.

#### 5.2.9. NaI(Tl) Internal Detector:

The MCA-465 uses a 1" x 2" sodium iodide detector coupled to a photo-multiplier tube with a light pipe. The voltage divider and coupling capacitor are mounted on the PMT socket and the detector assembly is then sealed light-tight.

## 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

It is recommended that a copy of the Configuration Tracking Sheet (Appendix D.) be filled out whenever the MCA-465 is put into service after tuning and recalibration.

### NOTE:

*Check the high voltage prior to calibrating the amplifier boards. The high voltage calibration will alter the amplifier outputs.*

*A test source is required for the following test. TSA recommends a 5 to 10 $\mu$ Ci  $^{137}\text{Cs}$  source, using a different isotope will require different gain settings. Contact TSA for the appropriate values if a source other than  $^{137}\text{Cs}$  is to be used.*

### WARNING:

*R16 is a factory adjustment. Do not attempt to adjust it in the field. This adjusts the dc offset of the peak detector to ensure linear response, and requires special test equipment to calibrate.*

## 6.1. CALIBRATION PROCEDURE

### 6.1.1. Calibration of High Voltage Power Supply:

Connect an oscilloscope between TP1 on the MCA-468 circuit board (the outer board of the board stack). Connect the ground lead to TP3. Place a  $^{137}\text{Cs}$  source under the center of the bottom of the case.

Adjust the high voltage on R44 for +1 volt pulse amplitude at TP-1.

#### NOTE:

*If a 1 volt pulse amplitude cannot be obtained, the MCA-468 circuit board or detector is faulty and should be replaced.*

### 6.1.2. Amplifier Calibration:

Prior to adjusting the amplifier gain, enter the Field Calibration Mode and set the field calibration value to 240. Move the cursor to the desired channel on the MCA screen. (For Example: channel 83 to calibrate using  $^{137}\text{Cs}$  with the internal detector)

Select Calibrate from the SET-UP MENU.

Press the "STORE" switch to set the calibration factor at 240.

Press the "ENTER" key to store this value.

#### Lower level discriminator adjustment:

Connect a DVM between TP5 (+) and TP8 (-).

Adjust R19 for a reading of 0.200 Vdc.

Amplifier offset adjustment:

Disconnect the input to the amplifier (J1 on the MCA-468 circuit board).

Connect a DVM between TP2(+) and TP4(-).

Adjust the offset pot R10 for -0.006 Vdc.

Reconnect the input to the amplifier.

Coarse gain adjustment:

Connect the scope probe from TP2 to ground.

Adjust R6 for a 4.5 volt pulse amplitude.

Remove the scope probe.

6.1.2.1. Begin Scan:

With the calibration source still under the center of the bottom of the case, press the "START" switch to begin a scan. While observing the display, adjust R6 until the peak energy appears in channel 83.

6.1.2.2. Stop Scan:

Stop the scan, disconnect the input (J1), and verify the offset at TP2 is still -0.006 Vdc; adjust R10 if necessary.

Repeat sections 6.1.2.1. and 6.1.2.2. until both conditions are satisfied.

6.1.3. Field Calibration:

Refer to Calibrate (3.4.1.4.) for details on "Fine Tuning" the calibration in the field.

6.1.4. Low Battery Warning:

Connect a DVM from TP18 to ground. Turn on the unit and adjust R28 for a reading of 3.5 volts.

## 7. TROUBLESHOOTING

This guide is designed so that on-site personnel can service the MCA-465 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 repairs are completed and the unit returned to operation, a copy of the Performance Verification Checklist (section 6.3.) should be filled out and filed for future reference.

### NOTE:

*Before any troubleshooting procedures are attempted, ensure that batteries are fully charged. Voltage on J7, pin 1 on the MCA-468 circuit board should be at least 11.5 volts.*

If the instrument fails to power up, or if it gives no visual indication of having powered up, follow the troubleshooting procedures given below, in the order listed.

If the instrument powers up and appears to be functioning normally, but the spectral data on the display is suspect, or if no spectral data is displayed, run the calibration procedure described in Maintenance (section 6.1.).

If unit powers up normally, but one or more of the front panel switches seems to be not working correctly, verify that the Low Voltage Power Supply (section 7.1.) is functioning, as described.

If voltages are normal, refer to Front Panel Switch Tests (section 7.4.).

## 7.1. VERIFICATION PROCEDURES

### 7.1.1. Low Voltage Power Supply:

With the power off, open the instrument by loosening the six screws on the front panel. The screws are captive, and need not be fully removed. Lift off the cover and invert it towards the top of the case.

The circuit boards are mounted inside the cover. Using a DVM, verify that the +5 and  $\pm 15$  Volt supplies are within 5% of nominal voltage, as measured on the Test Points along the upper edge (nearest the case bottom) of the MCA-468 circuit board (the higher board on the stack).

#### NOTE:

*If any of the positive voltages measure high, the MCA-468 board is faulty and should be replaced.*

If the -15V supply is excessively high and the +15V supply is not, there may be too much load on the +15 supply. Only the positive output from the  $\pm 15$ V regulator is used as feedback.

Similarly, if any of the supply voltages are low, either the regulator may be faulty or there may be excessive load on the supply. To test for this, it will be necessary to separate the board stack.

Remove the battery power from the board stack by disconnecting the battery from J7 on the MCA-468 board. Remove the four screws at the corners of the board, and carefully separate the two inter-board connectors, J3 and J4. Make sure that the MCA-468 board is insulated from the case and the MCD-467 board beneath it, then reconnect battery power at J7.

Power up the MCA-468 board by momentarily shorting J4, pin 2 to ground. This simulates the closing of the front panel ON/OFF switch. (If the lid of the instrument is sitting above the case bottom, J4 is at the left end of the lower edge, and pin 1 is at its left end, nearest the center of the board.)

NOTE:

*If the voltages are now correct, the MCD-467 board is faulty, and should be replaced.*

*If the voltages are still out of tolerance, replace the MCA-468 board.*

7.1.2. High Voltage Power Supply:

With the board stack fully assembled, but the cover removed, power up the instrument and, using a DVM with a high-voltage probe of at least 1,000 megohms impedance, verify that the voltage at J6, pin 1 on the MCA-468 board is between 600 and 900 Volts.

NOTE:

*If the voltage is outside this range, and cannot be adjusted over this range by adjusting R44, the MCA-468 board is faulty and should be replaced.*

If the High Voltage is working properly, but a pulse height of +1.0V at TP1 cannot be achieved as described in Maintenance (section 6.), set R44 for a high voltage of around 700 volts. Check for output pulses from the Detector assembly, as described in Detector Output Pulse Test (section 7.1.3.).

7.1.3. Detector Output Pulse Test:

To verify the Detector assembly is functioning correctly, insure that the High Voltage to the detector is in the range of 600 to 900 Volts. Then, with the instrument running, remove the signal cable from J1 of the MCA-468C circuit board.

Using an oscilloscope probe of at least 10 Megohm impedance (standard X10 probe), check for negative-going pulses of at least 10 mV peak from the signal cable plug. Small pieces of wire or resistor leads can be used to reach the contacts inside the signal cable housing. Ground is the contact with the 22AWG black wire attached.

NOTE:

*If pulses are coming from the detector, but a 1 volt signal cannot be obtained at TP1, the MCA-468 circuit board is faulty and should be replaced.*

*If pulses are not present, replace the detector assembly.*

7.1.4. Front Panel Switch Test:

NOTE:

*Two different overlay/switch configurations have been used on the MCA-465 instruments. The newer overlays have integral switches and may be identified by the embossed switches. The embossed switches are raised approximately 1/32" (.030") higher than the front panel.*

*On the Earlier Units (section 7.1.5.), the front panels are completely flat and the switches are separate from the overlay.*

To verify that the front panel switches are functioning properly, separate the board stack as described in Amplifier Calibration (section 6.1.2.) for testing the Low Voltage Power Supply.

The front panel switches are interfaced to the MCD-467 board by two flat ribbon cables. Proper switch operation may be tested using an ohmmeter. Connect the ohmmeter to the connector pins as designated in the following table.

SWITCH TESTS		
Switch	Common	Signal
Power	J3-2	J3-1
Mode	J3-6	J3-4
Start	J3-6	J3-5
Store	J3-6	J3-7
Enter	J3-6	J3-8
↑ (Inc)	J4-3	J4-1
↓ (Dec)	J4-3	J4-2
←	J4-3	J4-4
→	J4-3	J4-5
Light	J4-8	J4-7

There should be continuity when the switch is pressed, and an open circuit when the switch is released.

If any switch fails to operate correctly, the instrument should be returned to TSA for repairs.

If the individual switches operate correctly, but the instrument fails to respond when one or more switches are pressed, check the connectors and cables for corrosion or dirty contacts.

**NOTE:**

*If no problems can be found, the MCD-467 circuit board is probably faulty and should be replaced.*

#### 7.1.5. Early Units:

Each bank of four switches connects to the MCD-467 board by a single cable.

J3 connects to the cursor (arrow) switches.

J4 connects to the function switches.

The backlight switch connects via its own cable to J7.

The ON/OFF switch connects to J6.

Disconnect the cable from the switch or bank to be tested, and using an ohmmeter, verify continuity when the switch is depressed and an open circuit otherwise.

On the four switch banks, "common" is the center conductor in the cable. The other conductors wire direct (left switch to left conductor, etc.).

**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**

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**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.

$\text{Alarm Level} = ( N * \sqrt{\text{bkg}} ) + \text{bkg}$	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.

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

C.5. SIGNAL TO BACKGROUND RATIO

The following formula is helpful in 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.

$\bar{R} = \frac{R}{I}$  $R = \frac{S^2 - \bar{C}}{\bar{C}}$	Where:	R = the quality factor
		$S^2 = \text{variance} \frac{\sum (C - \bar{C})^2}{N - 1}$
		C = each of the individual counts
		$\bar{C} = \text{the mean of the counts} = \frac{\sum C}{N}$
		N = number of counts taken
		– 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 prompts, 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.  
14000 MEAD STREET  
LONGMONT, COLORADO 80504-9698  
970.535.9949  
FAX: 970.535.3285**

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**F. DRAWINGS**

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

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