MULTI-CHANNEL ANALYZER

MODEL mMCA-430

OPERATING AND SERVICE MANUAL

Version 1.11z

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mMCA-430

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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 mMCA-430. 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

The mini-MCA, model mMCA-430 incorporates a 256 channel multi-channel analyzer with a NaI(Tl) detector and a neutron rate meter with a LiI(Eu) detector in a small package. This is a "field grade" instrument designed to determine what radioisotopes are present during a scan. The mMCA-430 is used to determine the energy level (in keV) of gamma emitters. The level of neutron activity may be used in conjunction with the gamma spectrum to assist in identifying the isotope(s).

The mMCA-430 takes advantage of state-of-the-art components where possible. The digital section uses an upgraded version of the Z8 microcontroller and a highly integrated programmable logic device. The analog section combines the advantages of low power, high speed operational amplifiers with a fast, low-power analog to digital converter. The power supplies (low and high voltage) use high efficiency switching regulators.

The 100 x 32 pixel liquid crystal display displays both text and graphics. Power for the unit is provided by six alkaline "AA" cells mounted in a battery pack on the end of the instrument. A rechargeable lead acid battery with a universal charger is available as an option. The instrument will operate for 8 to 12 hours on a set of batteries, or a recharge. The instrument may be operated from ac line power using the charger/power supply. The power supply is included with the rechargeable option, but must be ordered separately for the standard instrument.

The internal display provides the operator with a quick look at the spectrum in real time. The physical size of the display makes data analysis impractical; each pixel must represent the average of three channels of data to permit viewing the full spectrum in the field. The data must be downloaded to a PC for detailed analysis.

Both OS/2 and Windows-based communications software is included with the instrument. Data may be downloaded to a PC for viewing or conversion to ASCII. The ASCII file can be imported by many third-party programs for further analysis.

1.3. SAFETY PRECAUTIONS

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

WARNINGS:

The mMCA-430 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 mMCA-430 should not be dropped or subjected to severe mechanical shock.

1.4. SPECIFICATIONS

Detector:	Gamma detector: 1" diameter x 2" (2.5 x 5cm) NaI(Tl) crystal Neutron detector: 1" diameter x 0.2" (2.5 x 0.5cm) LiI(Eu) crystal
Display:	LCD, 0.8"h x 2.1"w (2 x 5.2 cm) 32 x 128 pixels; 4 x 16 characters
Keypad:	12 key (telephone style)
Communication:	RS-232C interface; 9600 bps; Windows™ based software
PROM:	64 kBytes
RAM:	2 kBytes
NVRAM:	128 kBytes (battery backed) 2 kBytes with clock/calendar (battery backed)
Data Storage:	159 gamma spectra and neutron counts
Power:	
Internal:	Standard Six, "AA" size alkaline cells. will provide a minimum of 12 hours of operation
Rechargeable:	6 volt, 4.5Ah, lead-acid battery with 90 – 250 volt, 47 – 63 Hz. A universal input power supply/battery charger is included. Recharge time is typically 16 hours.
Battery life:	More than 12 hours of normal operation on a full charge
High voltage:	500 - 1,000 Vdc

Scan Time:	1 to 9999 seconds.
Background Time:	
ADC time:	1.6 µseconds
Serviceability:	Unit can be serviced to the subassembly level in the field
Dimensions:	
Standard:	10"h x 4.75"w x 3"d (25 x 12 x 7.6cm)
Rechargeable:	9.5"h x 4.75"w x 4"d (24 x 12 x 710cm)
Weight:	
Standard:	≈3 lb (1.4kg)
Rechargeable	≈5 lb (2.3kg)
Environmental:	
Temperature:	32˚ to 100˚F (0˚ to 38˚C)
Humidity:	Up to 95% non-condensing
Optional Case:	
Standard:	4.75" x 10" x 3" (11.9cm x 25cm x 7.5cm); polycarbonate (including battery pack)
Rechargeable:	4.75" x 9.5" x 4" (12cm x 24cm x 10cm)

2. INSPECTION AND SETUP

The following procedures should allow on-site personnel to correctly install and set up the mMCA-430 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 VM-250A 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

The standard mMCA-430 is powered by six "AA" alkaline batteries. The batteries are installed in a holder mounted on the base of the instrument. To open the battery compartment, loosen the four knurled screws at each corner of the compartment, and remove the cover. The battery holder can now be lifted out of the compartment. Remove the old batteries and replace them with a fresh set.

NOTE:
Observe the battery polarity marked on the holder.

For instruments equipped with the rechargeable battery option, plug the battery charger into an ac receptacle and allow to charge for 16 hours.

NOTE:
The charger may be plugged into any 90 - 250 volt, 47 - 63Hz outlet. No switching is required.

The power switch is located on the right side of the instrument. Press the front of the switch to turn the instrument on. The mMCA-430 will display the information that was in memory when it was turned off. It is now ready for operation.

Press the "*" key to clear the display and start accumulation. The unit will scan for the programmed count time and stop. A tone is emitted at the end of each scan. The "#" key stops accumulation.

In the graphics display mode, the mMCA-430 will auto-scale the display. When one channel exceeds the vertical range of the display, the scale will be doubled. ROI 5 can be used to limit the auto-scale to areas that are of interest to the operator. This will allow energies that are outside ROI 5 to "flat top", while the rest of the spectrum will be displayed in the maximum scale possible.

3.1. DISPLAY MODES

The mMCA-430 offers five display modes. The display modes are selected by pressing the number key associated with the desired mode. The display modes do not change the status of the instrument. A short description of each display mode follows:

1. Count Rate:

   The count rate mode displays the gamma and neutron count rate in counts/second and total counts for the current scan. In this mode, the gamma counts are from the gamma counter, not the pulses that have actually been converted by the ADC. The ADC counts may be lower than the actual count rate due to ADC "dead time". The magnitude of this phenomenon is count rate dependent; in higher count rates a higher percentage of pulses will not get converted.

2. ROI (Regions of Interest):

   The first column shows the integral of ROIs one and two and the total neutron counts for the current scan. The second column shows the current count in counts/second. The ROI numbers will be prefixed with an "S" if peak strip is enabled.

3. Graphics:

   The graphics mode shows the current gamma spectrum. Due to the limited number of pixels in the display each pixel represents the average count of three adjacent channels.

4. Count Rate with Bar Graph:

   This mode displays the counts/second for both gamma and neutron, with a horizontal bar graph below each. In this mode, the gamma counts are from the gamma counter, not the pulses that have actually been converted by the ADC.

5. Status:

The status mode displays the current system status. The first line indicates whether the instrument is in STANDBY or COUNT mode. The second line reports the battery status; either OK or LOW. The third line counts down the seconds to POWER SAVE mode.

3.2 SEARCH/FIND OPERATION

The Search/Find operation is selected and initiated by pressing the number key "6".

When the Search/Find operation is initiated, the current count, in cps, is shown on the first line of the display. The third line displays either SEARCH or FIND. The count is updated once per second, so the instrument should be moved fairly slowly for search/find operation.

In this mode, the instrument takes a twenty second background, then enters the search mode of operation. The instrument emits a short tone when the background is completed. The search mode alarm is 4 sigma above background. When the alarm threshold is reached, the instrument will emit an audible tone.

Pressing the "6" key toggles between search and find. The find mode tone steps to a higher frequency tone for each 1 sigma increase above background. The tones start at approximately 800Hz, and increases in frequency until 2,500Hz is reached.

Pressing a key between 1 and 5 exits the Search/Find operation. A new background will be acquired each time the Search/Find mode is initiated.

3.3. STORING DATA

The spectrum may be stored selectively or automatically after each scan. Selective storage is activated by pressing the "7" key. The operator will be informed how many data areas are available and prompted to press "1" or "2". Pressing "1" will store the spectrum, "2" will abort the current storage operation and exit the store menu. Stored data may be downloaded to a PC for archival or further analysis.

When automatic storage is enabled, the operator is presented with the option to store the data after each scan is complete.

3.4. PROGRAM MODE

The program mode allows the operator to set the various parameters in the mMCA-430. Press the "0" key to enter the program mode. The instrument will display three menu options per screen. The fourth line prompts the operator to press "0" for the next three parameters, or "#" to exit the program mode.

Pressing the number key from the menu displays the current value of that parameter. The operator may press the "#" key to leave the value unchanged and return to the menu, or type in a new value and press the "#" key to change the value.

While the instrument is in the data entry mode, the "*" key clears the current entry and the "#" key accepts the current data. Pressing the "#" from the menu exits the program mode.

There are 9 programmable parameters.

PROGRAMMABLE PARAMETERS		
SET ROI 1-5	POWER SAVE	AUTOSTORE
COUNT TIME	SET CLOCK	TEST KEYPAD
RATE SCALES	PEAK STRIP	ERASE DATA

The parameters are described in detail as follows:

1. Set ROI 1-5:

   Programs the lower and upper channel for Regions of Interest 1 through 5.

   NOTE: *ROI 5 is used to program the "auto ranging" mode of the display."*

   The mMCA-430 will only auto-scale on the portion of the spectrum that fall within

   the boundaries of ROI 5.

2. Count Time:

   Sets the count time, the range 1 to 32,564 seconds. Setting this value to "0" selects manual scan mode, the instrument will scan until the "#" key is pressed.

3. Rate Scales:

   Sets the full scale (in cps) for the two bar graph displays. Rate scale 1 is for the gamma channel and rate scale 2 is for the neutron channel.

4. Power Save:

   Sets the time, in seconds. The unit will remain active before entering the "power save" mode. Power save mode halts the processor and minimizes digital activity to

   conserve battery power. Pressing any key will "wake up" the instrument.

   NOTE: *Setting Power Save time to 0 disables the power save mode.*

5. Set Clock:

Sets the clock/calendar. The operator will be prompted to enter the hours (24 hour
format), minutes, month, date, and year using the keypad.

6. Peak Strip:

Turns the peak strip feature on or off. The operator will be prompted to enter 1 to enable, or 0 to disable peak stripping. When peak stripping is enabled, the ROI numbers are prefixed with an "S".

Peak stripping removes the counts in the area below where the ROI boundaries intersect the spectrum. The instrument calculates a slope that connects the upper and lower ROI boundaries, only the counts that fall above this slope are reported for integral of the ROI when peak strip is enabled.

7. Autostore:

When autostore is enabled, the operator is automatically prompted to press 1 (to store) or 2 (not to store) the data after each scan.

8. Test Keypad:

Echoes the numeric keys and the "*" key (as 10) to the display. Pressing the "#" key exits the test.

9. Erase Data:

Erases the data in all storage areas. The operator must confirm this operation by pressing 1 to erase, or 2 to abort the operation.

4. PC COMMUNICATIONS

NOTE:
Attempting to communicate with mMCA-430 when it is in power save mode may cause the PC application to lock up. Press a key on the mMCA-430 before communications are started.

The mMCA-430 is equipped with an RS-232 port to permit communications with an IBM compatible PC running either OS/2 or Microsoft Windows.

Copy the program (MMCACOM.EXE) to the windows directory. Run the program.

MENU OPTIONS
Times
ROI's
Data
Control
Set-Up

The miniMCA Communications Program will present these five options on the pull- down menu

The menu options in the miniMCA Communications Program are described in detail below:

Times:

The Times menu option allows the operator to view or set Time of Day, Date, Acquire Time, and Power Down time. These are the same as count time and power save time in the programming section of this guide. (section 3.3. Program Mode)

ROI’s (Regions of Interest):

The Regions of Interest option allows the operator to set the low and high channels for the five ROIs. This accomplishes the same function as ROI in the programming section of this guide. (section 3.3. Program Mode)

Data:

The Data option allows the operator to View, Erase or Translate data.

View:

Allows the operator to view the current scan or any of the data storage areas in the MCA. Selecting this option will present a directory of the current data areas in the mMCA-430. Move the pointer to the desired data area, click on the area, then click on the "OK" box to view the file.

The spectrum from the selected file will be displayed with the ROI boundaries and the integrals of each ROI. The operator can select a channel using the mouse, and click the left button to display the channel number and counts in that channel.

The area may be saved to disk by clicking on the Save box. The operator will be prompted to either accept the default file name or type in a new one. The data are saved in a single column ASCII file that can be imported into many spreadsheet, data base, and statistical programs for post processing.

Erase:

Allows the operator to erase data areas from the mMCA-430's memory. Selecting this option will present a directory of the current data areas in the mMCA-430. The data areas to be erased may be selected from the file list or all areas may be erased by selecting all areas from the list.

Translate:

Allows the operator to convert data areas into ASCII files to allow the data to be imported into data analysis software. Selecting this option will present a directory of the current data areas in the mMCA-430. Select the area to be translated from the file list, enter the desired file name when prompted and click on "OK". The data will be written to the file as 256 lines of ASCII numbers. The first line contains the total neutron count for the scan, and each successive line represents the counts beginning with channel 1 and ending with channel 255.

Control:

The Control menu option allows the operator to start, stop and store scans from the PC. The five display modes can also be selected using the PC.

Set-Up:

The Set-Up menu option allows the operator to select which serial communications port (Com 1 to Com 4) the PC will use for communicating with the mMCA-430.

5. THEORY OF OPERATION

The mMCA 430 instrument is a hand held monitor combining a full function, 256 channel field grade multi-channel analyzer and neutron counter in one compact unit.

5.1. MMCA-410 BOARD OPERATION

The mMCA-410 board contains all of the circuitry in the mMCA-430 except the high- voltage power supply.

U14 is a regulated, switching power supply. It converts the 4 to 10 volt battery input to a regulated +5Vdc to power the system.

U12 converts the +5Vdc input from U12 and inverts it to produce approximately -5 Vdc for the portions of the system that require a negative power supply.

U5 is the microcontroller that performs all of the calculations and control of the instrument.

U9 is a programmable microcontroller peripheral that stores the program, provides the stack memory, manages address decoding, as well as a variety of other tasks. There are three counter timers used in both U5 and U9.

U1 and U2 provide the non-volatile RAM for the system. Both ICs have integral lithium batteries to preserve data, even when the instrument is turned off. U2 stores the operating parameters and performs the clock/calendar functions. U3 is used for data storage.

U15 is the keypad decoder. The signals from the keypad are decoded in this device and the resulting binary codes are sent to the processor (via U9).

U6, a micro-power ADC, monitors the battery voltage and sends the information to the microcontroller.

U11 is a watchdog circuit. It provides the power up reset timing for the logic, and will reset the microcontroller if the program ceases to execute properly.

U13 is a level shifter for the RS-232 interface. It accepts logic level inputs and converts them to RS-232 output levels, and vice-versa.

U4, dual operational amplifier, amplifies the signal from the PMT on the NaI(Tl) detector. The amplifier output is coupled to the input of U6 (ADC) and U8A (gamma LLD). The LLD output is counted in U9, and starts an analog to digital conversion in U6.

U6 converts the peak amplitude of each incoming pulse to a binary number between 0 and 255. This number is sent to U7. U7 adds one count to the appropriate channel for the current spectrum.

If U8 has not finished the previous conversion, the incoming pulse is counted, but not converted to a digital value for use with the spectral data. The count data is only available in the two count rate display modes (1 and 4).

U7, dual operational amplifier, amplifies the signal from the PMT on the optional LiI(Eu) detector. The amplifier output is coupled to the input of U8B (neutron LLD). The neutron pulse is counted in U9, no spectral information is generated for the neutron signals, the count data may be viewed in the two count rate display modes, and is stored with the spectrum.

5.2. HIGH VOLTAGE POWER SUPPLY

The standard mMCA-430 uses a HHV-454 board to supply high voltage for the PMTs.

On rechargeable instruments, a DHV-001 is used to supply high voltage for the PMTs.

Both power supplies convert the battery voltage to a regulated voltage of approximately 700Vdc for the PMTs in both detectors.

5.3. MULTI-CHANNEL SPEAKER DRIVER

The Multi-Channel Speaker Driver generates the audio tones and provides the contrast voltage to the display.

U1 generates a frequency of approximately 7k Hz. This signal is input to U2, where it is divided by a factor of 2 to 14, depending upon the state of IN2 through IN5. The output of U2 directly drives the transducer.

U3 is dc-dc switching power supply which provides -20 volts for the display contrast. The -20 volts is applied to one end of R1. R1 allows the contrast voltage to be adjusted from 0 to -20 volts.

5.4. GAMMA DETECTOR

The gamma detector is a 1" x 2" NaI(Tl) crystal coupled to a PMT with a light pipe. The voltage divider is an integral part of the detector.

5.5. NEUTRON DETECTOR (OPTIONAL)

The neutron detector is a 1" x 0.2" LiI(Eu) crystal coupled to a PMT with a light pipe. The voltage divider is an integral part of the detector.

6. MAINTENANCE

The mMCA-430 is calibrated for a full-scale energy of 2 MeV when it is shipped from the factory. If a different full-scale energy is required, the mMCA-430 must be recalibrated. In any case, the calibration should be verified before the unit is put into service.

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 mMCA-430 is put into service after repair or prolonged storage.

Refer to the appropriate schematic diagrams and component designators as required. (Appendix F.).

WARNING:
These procedures expose the technician to high voltage, and should only be performed by qualified personnel.

6.1. OPERATOR MAINTENANCE

6.1.1. Component Access:

Refer to "mMCA-430 Exploded View (standard unit)" Drawing 2 and "mMCA-430 Wiring Diagram (standard unit)" Drawing 3 (Appendix F.).

Remove the lid of the instrument by removing the four screws at the corners of the lid. Gently separate the lid from the base of the instrument, taking care not to damage the wires.

6.1.2. mMCA-410 Board:

Refer to "mMCA-410A Schematic Diagram" Drawing 6 and "mMCA-410A Component Designator" Drawing 7 (Appendix F.).

The mMCA-410 board is mounted to the lid. For board circuitry information, refer to mMCA-410 Board Operation (5.1.).

6.1.3. Detectors and Power Supply:

The detectors and high voltage power supply are located in the base of the instrument.

WARNING:

These procedures expose the technician to high voltage, and should only be performed by qualified personnel.

6.2 CALIBRATION

NOTE:
The high voltage must be properly adjusted before attempting to calibrate the amplifier circuits.

There are several ground test points on the mMCA-410 board. The oscilloscope probe should be grounded at the nearest ground test point to ensure accurate readings.

6.3. HIGH VOLTAGE ADJUSTMENT

The instrument will have either a HHV-454 or a DHV-001, depending upon whether it is rechargeable or not. Use the appropriate procedure for the instrument being calibrated.

6.3.1. HHV-454:

Refer to "HHV-454 Schematic Diagram (standard unit)" Drawing 8 and "HHV-454 Component Designator (standard unit)" Drawing 9 (Appendix F.)

HHV-454 Monitor TP1 on the mMCA-410 board with an oscilloscope. Place a ^{137}Cs source (5 - 10 µCi activity) near the gamma detector.

Verify a peak pulse amplitude of 3 volts ±0.1 volt.

If the pulse amplitude is out of specification, adjust R5 on the HHV-454 board until the proper pulse amplitude is achieved. R5 may be accessed through the hole in the copper shield on the HHV-454 board.

6.3.2. DHV-001:

Refer to "DHV-001 Schematic Diagram (rechargeable unit)" Drawing10 and "DHV-001 Component Designator (rechargeable unit)" Drawing 11 (Appendix F.).

DHV-001 Monitor TP1 on the mMCA-410 board with an oscilloscope. Place a ^{137}Cs source (5 - 10 µCi activity) near the gamma detector.

Verify a peak pulse amplitude of 3 volts ±0.1 volt.

If the pulse amplitude is out of specification, adjust R10 on the DHV-001 board until the proper pulse amplitude is achieved.

6.4. GAMMA AMPLIFIER GAIN

NOTE:

The oscilloscope input must be ac coupled when the gain is adjusted.

Connect the oscilloscope input to TP3. With the ^{137}Cs source still near the gamma detector, adjust R1 for a peak pulse amplitude of 4.75 volts ±0.1 volt.

Move the ^{137}Cs source away from the instrument.

6.5. GAMMA LLD ADJUSTMENT

Connect a DVM between TP3(-) and TP7(+) adjust R9 for a reading of 0.30 Vdc ±0.01 volt.

6.6. NEUTRON AMPLIFIER SET-UP

6.3.1. Input attenuator adjustment:

Connect the oscilloscope input to TP5. Place a neutron test source near the moderator for the neutron detector. Verify a peak pulse amplitude of 342 volts. If the amplitude is too high, adjust R11 to reduce the pulse amplitude.

6.3.2. Neutron amplifier gain:

Connect the oscilloscope input to TP6. With the neutron source still near the neutron detector, adjust R12 for a peak pulse amplitude of 2 - 2.8 volts. Remember the actual amplitude as it will be necessary in setting the neutron LLD.

6.3.3. Neutron LLD adjustment:

Connect a DVM between TP8(+) and ground, adjust R13 for a reading of 0.7 * the peak amplitude recorded in step 6.3.2.

7. TROUBLESHOOTING

The mMCA-430 uses highly integrated parts to reduce the size of the instrument. It is designed so that on-site personnel can service the mMCA-430 and effect necessary minor repairs. This manual supports troubleshooting to the board or subassembly level. Any other problems should be referred to factory authorized service personnel. Unauthorized repair voids warranty.

Both U9 and U15 are programmable devices, and are only available from TSA. The other components are available commercially, and may be replaced by qualified service personnel.

When repairs are completed and the unit returned to operation, a copy of the Performance Verification Checklist (section 6.7) should be filled out and filed for future reference.

WARNING:
The following procedures expose the technician to high voltage, and should only be performed by qualified personnel.

7.1. INSTRUMENT FAILS TO POWER-UP

Follow the instructions below if the instrument will not power up.

Test the Battery:

Test the battery with a DVM with the instrument turned on.

For a standard unit, the battery voltage must be at least 6Vdc, 5.4 volts with the rechargeable option.

NOTE:
Do not continue troubleshooting until the battery voltage is correct.

Measure the Voltage:

Remove the cover of the mMCA-430.

Measure the voltage between mMCA-410 J4- 1(+) and J4-10(-) with a DVM.

This voltage must be ?6Vdc (5.4 with rechargeable option).

If the voltage is low, check the switch and wiring to the battery pack.

Repair or replace the defective component.

Confirm the Board is Defective:

If the battery voltage is getting to the mMCA-410 board and the unit is still dead, the mMCA-410 board is defective and must be replaced.

7.2. LOW COUNT RATE

7.2.1. One Channel:

If either the gamma or neutron channel count rates are low, and the other channel is normal, the problem is in the appropriate amplifier channel on the mMCA-410 board.

Calibrate the instrument as outlined in section 6. Maintenance of this manual. If calibration does not correct the problem, the mMCA-410 board is probably defective and must be replaced.

7.2.2. Both Channels:

If both the gamma and neutron count rates are low (or zero), the high voltage power supply is probably out of calibration or defective.

Calibrate the instrument as outlined in Maintenance (section 6.). If calibration does not correct the problem, the HHV-454 board is probably defective and must be replaced.

7.3. DISPLAY IS DIFFICULT TO READ

The display may be difficult to read in extremely cold conditions. Take the instrument into a warm (50˚F) area and allow it time to warm up. If the display is still difficult to read, remove the cover and adjust the contrast control. The contrast control is R1 on the MSD-001A board.

7.4. GENERAL TROUBLESHOOTING GUIDE

NOTE:
Some steps will require tools, supplies, DMM, and possibly an oscilloscope. These steps should only be performed by qualified service personnel.

Perform a physical inspection of the unit, looking for faulty or broken wiring, foreign material, broken or damaged components, and loose connections.

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.

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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.

$\text{Alarm Level} = \left(N * \sqrt{\text{bkg}} \right) + \text{bkg}$	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
		$S^2 = \text{variance} \frac{\sum (C - \overline{C})^2}{N - 1}$
		C = each of the individual counts
$\mathbf{R} = \frac{S^2 - \overline{C}}{\overline{C}}$		$\overline{C} = \text{the mean of the counts} = \frac{\sum C}{N}$
		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.
14000 MEAD STREET
LONGMONT, COLORADO 80504-9698
970.535.9949
FAX: 970.535.3285

F. DRAWINGS

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