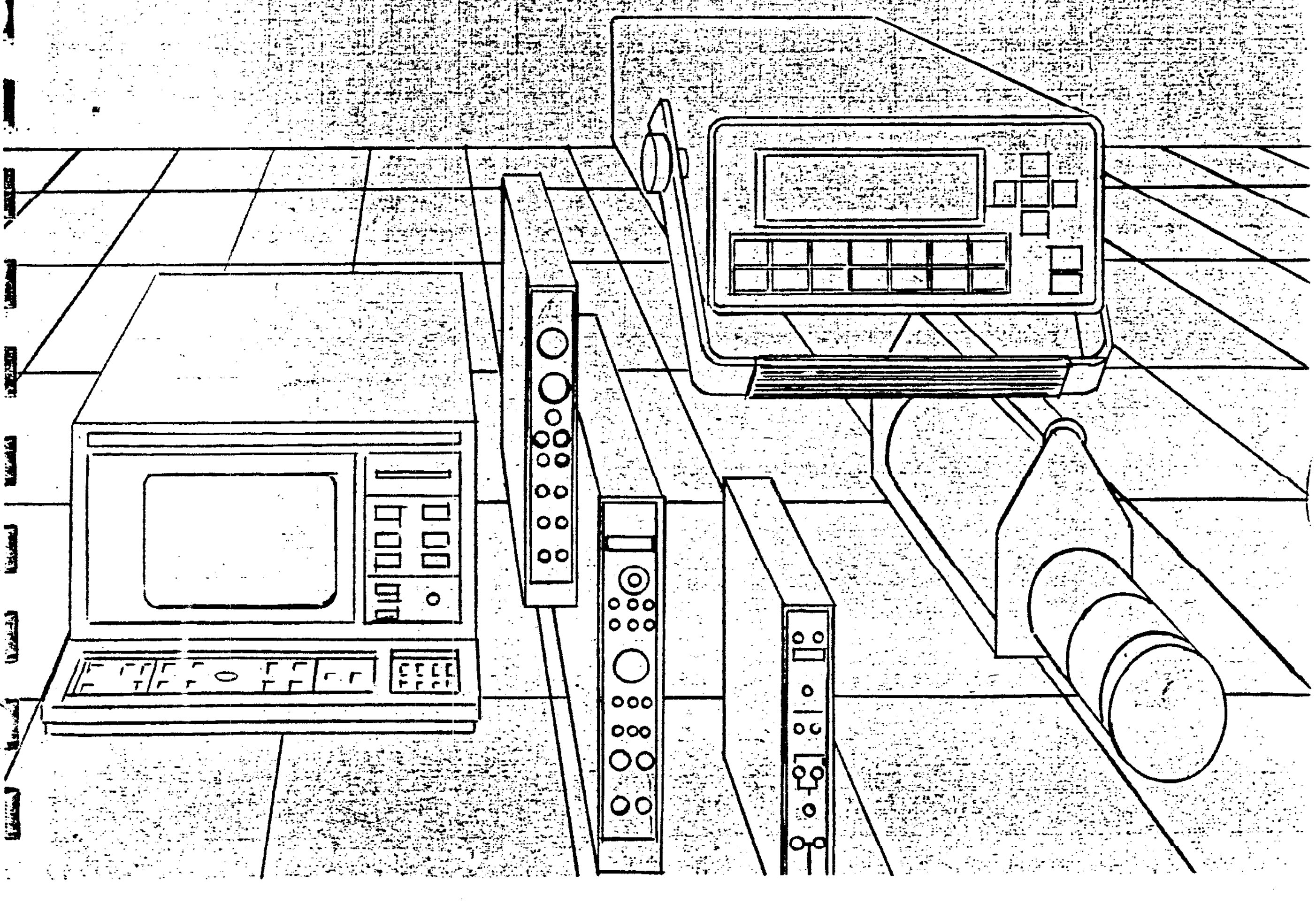
CANBERRA

SERIES 20
MULTICHANNEL ANALYZER

1288

Operator's Manual



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Operator's Manual

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Publishing History

Manual Version	Changes Made	Date	Firmware Versions
1.0	First release	August, 1984	2801/02-A3
1.1	Add appendix on AP-PAKs; reorganize Appendix B	September, 1984	2801/02-A3
1.2	Add the Index and Recycle Function	December, 1984	2801/02-A3
1.3	Change MDA equation	May, 1985	2801/02-A3
2.0	Add PC and Ext Control Interfaces	June, 1985	2801/02-B1
2.1	Clarify ECAL; update appendix A; add appendixes C.5 and K.4; expand appendix J, the Glossary, and the Index	November, 1985	2801/02-B1

PREFACE

Canberra's Series 20 Multichannel Analyzer (MCA) has a built-in 1000 volt High Voltage Power Supply which can power a wide range of detectors. The optional bolt-on NIM enclosure makes it easy to have an entire analysis package in a single unit. The Series 20 also offers a standard battery backup for the parameters memory and an optional battery backup for the data memory.

The Series 20's menu-driven approach and programmable "soft keys" give even the inexperienced user a friendly MCA that is easily and quickly set up to run data collection and analysis routines. Refer to section 1, Quick Start.

The Operator's Manual is organized so that it can be used by both the newcomer to nuclear analysis and the experienced MCA operator. It is divided into five sections and several appendixes for easy reference:

1. QUICK START	Following the directions in Quick Start will let you set up and run your Series 20 even if you have no previous MCA experience.
2. TUTORIAL	The Tutorial tells you about the Series 20's features and leads you through an example of Menu dialogue: setting the Series 20's clock.
3. FUNCTION KEYS	This section details the use of each of the front panel function keys.
4. REAR PANEL	All of the rear panel controls and connectors are covered here.
5. APPLICATIONS	This section will be helpful if you are unfamiliar with the ways an MCA can be used.
The APPENDIXES	These sections cover everything from Specifications to External Control Signals.
The GLOSSARY and the INDEX	These two sections provide definitions of terms and a ready reference to manual locations.

CLEANING NOTE A high-voltage induced static charge on the face of the display monitor can attract dust. The monitor and the Series 20's case can be cleaned with a soft cloth dampened with water.

Be careful not to let water get into the Series 20 while cleaning it or the display.

SECTION 1 QUICK START

This section tells you how to get the Series 20 up and running quickly. It includes • The setup procedures for the Series 20's two models • How to change the default Amp Gain • How to read data out to the Model 5421M Cassette Recorder.

The rest of this manual gives you more detailed information about operating the Series 20.

Refer to the Quick Card that came with your Series 20 for an overview of the Menu.

The Series 20 is available in two models.

The Model 2801 has 4096 memory channels and a 2048 channel ADC gain; it includes a Recycle function and is usually used with a Sodium Iodide (NaI) detector.

The Model 2802 has 4096 memory channels and a 4096 channel ADC gain; it includes Define/Use and Learn/Execute and can be used with either a Sodium Iodide or a Germanium (Ge) detector.

1.1 TURNING ON THE POWER

Before turning the Series 20 on, check the rear panel voltage selection card (in the rear panel fuse compartment). This is easily done by moving the plastic fuse shield to the left. The operating voltage will be visible directly under the fuse. It should be the same as your local ac line voltage.

If your Series 20 is not set for local line voltage, section 4.5 tells you how to change the operating voltage.

The Series 20's ac power switch is built into the front panel's INTENSITY control. Turn the control clockwise to turn on the Series 20. In a few seconds you will see the initial display. Figure 1.1 shows the display seen the first time the Series 20 is turned on.

For easier viewing, reach under the front of the Series 20 and pull down the hinged front feet.

```
CL= 0                 MEM  1/1                 FROM   2     TO 4095
CTS= 0                VFS  64                  INTG= 0



STATUS     COMPUTE    EXECUTE                  PSET(L)= 1000
 PAGE       TIME      TASK S1                  ELAP(L)= 0
```

Figure 1.1 Initial Display

1.2 DEFAULT PARAMETERS

Each setup procedure assumes that the MCA is using its default parameters. To insure that the default parameters are loaded into memory, press the following keys in the order shown:

- The MENU/EXIT key (to the right of the display)
- The ETC (numeral 5) key
- The DEFAULT (numeral 4) key
- The YES (numeral 1) key

Verifying Parameters

To verify that your MCA has loaded the default parameters, press the STATUS PAGE (numeral 1) key. The display will change to show the Status Page. Compare the display with figure 1.3 for the Model 2801 or figure 1.4 for the Model 2802.

With the default parameters loaded, go on to section 1.3 for the Model 2801 or section 1.4 for the Model 2802.

1.3 2801 SETUP

This section describes the setup for the Model 2801 with an input from a scintillation (NaI) detector, such as Canberra's Model 802 series.

The following equipment, or equivalent, is used for this setup procedure:

Model 2801 Series 20 MCA
Model 802 series Scintillation (NaI) Detector
Model 2007P Photomultiplier Tube Base/Preamplifier
Interconnecting cables as shown in figure 1.2

2801 Connections

Model 2801 AC IN to Power Main
Model 2801 HV OUT to Model 2007P HV
Model 2801 PREAMP POWER to Model 2007P PREAMP POWER
Model 2801 SIGNAL IN to Model 2007P OUT

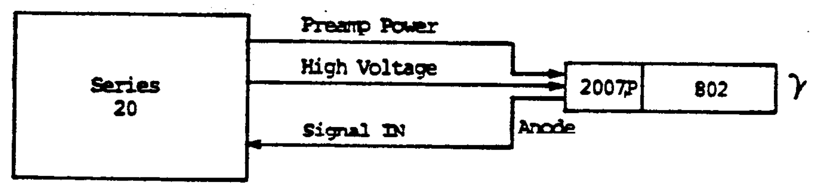


Figure 1.2
NaI System Setup

To start data collection:
1. Turn ON the Model 2801's rear panel HV ON switch.
2. Set the HV control for the detector's bias, listed on the paper enclosed with the detector (usually no more than 1000 V).
3. Place a radioactive source near the face of the Model 802 detector.
4. Press the COLLECT key to the right of the display.

The display will show data gradually increasing vertically. If the default Amplifier Gain doesn't produce a satisfactory spectrum, refer to section 1.5.

2801 Status Page

The Model 2801's Status Page display is shown in figure 1.3. The clock and calendar are not reset to default parameters.

The five labels at the bottom of the screen are used to change any of the parameters shown on the page. To activate a label for parameter modification, press the number key just below it.

CANBERRA SERIES 20 V2801-00

PRESET LIVETIME= 1000 SECONDS

MODE: IDLE TAGWORD= 0

AMP	SCA	ADC	EIA	CLOCK
GAIN 3.5000	LLD 0.000%	GAIN 2048	BAUD 300	DA/MO/YR 00/00/00
INPUT POS	ULD 110.0%	PHA ADD	LENGTH 7	TIME 00:00
SHAPING SLOW		OFFSET 0	PARITY EVEN	
		ZERO 0%	STOPBIT 1	CONTROL LOCAL

[AMP] [SCA] [ADC] [EIA] [CLOCK]

Figure 1.3 The Model 2801 Status Page

2802 Status Page

The Model 2802's Status Page display is shown in figure 1.4. The clock and calendar are not reset to default parameters.

The five labels at the bottom of the screen are used to change any of the parameters shown on the page. To activate a label for parameter modification, press the number key just below it.

CANBERRA SERIES 20 V2802-00

PRESET LIVETIME= 1000 SECONDS

MODE: IDLE TAGWORD= 0

CURRENT COMPUTE FUNCTION
F1=

AMP	SCA	ADC	EIA	CLOCK
GAIN 3.5000	LLD 0.000%	GAIN 4096	BAUD 300	DA/MO/YR 00/00/00
INPUT POS	ULD 110.0%	PHA ADD	LENGTH 7	TIME 00:00
SHAPING SLOW		OFFSET 0	PARITY EVEN	
		ZERO 0%	STOPBIT 1	CONTROL LOCAL
[AMP]	[SCA]	[ADC]	[EIA]	[CLOCK]

Figure 1.4 The Model 2802 Status Page

1.4 2802 SETUP

This section describes the setup for the Model 2802 with an input from a Germanium (Ge) detector.

The following equipment, or equivalent, is used for this setup procedure:

Model 2802 Series 20 MCA
Model 2882 NIM Enclosure
A Germanium (Ge) detector and Model 2001 Preamplifier
Interconnecting cables as shown in figure 1.5
Model 2861 High Voltage Power Supply (The 2861 is shipped set for POSitive high voltage; if your detector requires NEGative high voltage, refer to the 2861 manual.)

2802 Connections

Model 2802 AC IN to Power Main
Model 2802 PREAMP POWER to Model 2001 POWER
Model 2802 SIGNAL IN to Model 2001 ENERGY
Attach the NIM Enclosure to the MCA's left side
Put the Model 2861 in the NIM Enclosure
Connect 2861's power to Series 20's J102, EXT HVPS
Connect 2861's HIGH VOLTAGE to Model 2001 HV INPUT

To start data collection on the completed setup:

1. Turn ON the Model 2861.
2. Set the Model 2861's output for the detector's bias (see the label on the detector's neck).
3. Place a radioactive source on top of the detector.
4. Press the COLLECT key to the right of the Series 20's display.

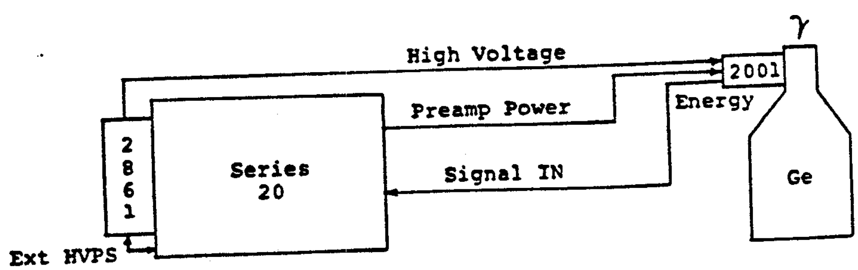


Figure 1.5
Ge System Setup

The display will show gradually increasing data. If the default Amplifier Gain doesn't produce a satisfactory spectrum, refer to section 1.5.

1.5 Changing Amp Gain

If the default Amplifier Gain doesn't produce a satisfactory spectrum, this is how you can change it. If Collect is active, press the COLLECT key to stop.

1. Press the STATUS PAGE (numeral 1) key. You'll see the Status Page and, at the bottom of the screen, a line of "soft" keys.
2. Press the "soft" AMP (numeral 1) key.
3. Press the "soft" GAIN (numeral 5) key in the new line of key labels.
4. Press the "soft" # (numeral 2) key in the new line, enter a new gain value, and press the "hard" ENTER key to the right of the display.
5. Now press the "soft" COLLECT (numeral 1) key. Data will start to accumulate, but the Dead Time Meter displayed at the top of the screen will read 100%. This means that you can't use the Preset function in "soft" Collect.
6. Repeat steps 4 and 5, entering a higher or lower number each time, until the spectrum is well positioned on the display.
7. The up and down arrows, next to the INDEX key, can be used to fine tune the Amp Gain while in "soft" Collect.
8. Press the "hard" MENU/EXIT key located to the right of the display screen.
9. Press the "hard" CLEAR DATA key below the screen. This will display two "soft" keys.
10. Press the "soft" DATA (numeral 1) key. The displayed data will be cleared from the screen.
11. Now press the "hard" COLLECT key to the right of the display. PHA data acquisition will start. In "hard" Collect, the Dead Time Meter will show the true dead time.
12. You can let data acquisition go on until the preset of 1000 Live Seconds has been reached (data acquisition will stop automatically).
13. Or you can press the "hard" COLLECT key again to stop acquisition at any time.

1.6 Cassette Readout

If you want to make a record of the collected spectrum, you can read it out to Canberra's Model 5421M Cassette Recorder.

1. Plug the Cassette Recorder's transformer into the ac power main and into the unmarked connector on the back of the Recorder.

2. Connect the 9-pin end of the supplied connecting cable to the Series 20's CASSETTE connector.

3. Connect the three plugs on the other end of the cable to the Model 5421's:
   EAR connector - black tagged plug
   REM connector - small gray plug
   MIC connector - large gray plug.

4. Insert a cassette tape in the recorder and rewind to the tape's beginning. To rewind, you'll have to pull the REM plug from its jack. Push the plug back in when the tape stops.

5. Press RECORD and PLAY on the Model 5421M and press the Series 20's "hard" READ key.

6. The default readout parameters (seen at power on) let you read all data out through the TAPE port (CASSETTE connector). Press the "soft" ACCEPT key to accept the default readout parameters and start the readout.

7. The Series 20 will show READ status at the top of the screen. When the readout is finished, the cassette tape will stop and the READ message will leave the screen.

8. If you want to try a readin, pull the REM plug from its jack, press REWIND on the Model 5421M, put the REM plug back in its jack when the tape stops, and press CLEAR DATA, and DATA on the Series 20. Press STOP on the Model 5421M.

9. Press PLAY on the Model 5421M. Press the Series 20's "hard" READ key, then the "soft" IN key. Select the TAPE "soft" key. Read in will start and the READ status will appear on the display.

10. When the readin is complete, you'll see the original spectrum on the screen.

This ends QUICK START. For more detailed information on operating your Series 20, refer to section 3.

SECTION 2 USING THE SERIES 20

This section covers • The Series 20's display • Using The Menu, with an example • Descriptions of the front panel controls • Scaling the display • The display functions • Input/Output • The Data ID • Data manipulation • System Reset.

Canberra's Series 20 multichannel analyzer (MCA) is available in two versions: Models 2801 and 2802. Both have all of the functions needed for standard spectroscopic pulse height analysis (PHA) and multichannel scaling (MCS), include diagnostic routines, and have a self-contained high voltage power supply (HVPS).

The Model 2801 has
- 4K channels of data memory
- 2K of ADC Gain
- Recycle function

The Model 2802 has
- 4K channels of data memory
- 4K of ADC Gain
- Function learn/execute
- Equation define/use
- Background Memory Readout

Verifying your Model Number

To verify which model number you are using, enable the Status Page: press the key below the STATUS PAGE label on the display. You'll see the model number in the center of the Status Page's top line: either V2801 or V2802, followed by the installed firmware version (shown as a letter and a number). This manual covers firmware version B1.

Easy to Use

The Series 20 is remarkably easy to use, even for beginners: it offers a list of function choices, called a menu, on its display. You program the Series 20 by choosing items from the menu. The Series 20 will then perform the functions you have programmed it for.

Using the procedure for setting the internal clock, section 2.6 gives you an example of how to use the menu to program the Series 20.

2.1 POWER UP

Before applying power, check the rear panel voltage selection card (inside the rear panel fuse compartment) to be sure that it's set for your local line voltage. This is easily done by moving the plastic fuse shield to the left and looking directly under the fuse; the operating voltage will be visible. Section 4.5 tells you how to change the operating voltage.

The Series 20's ac power switch is built into the front panel's INTENSITY control. Turn the control clockwise to turn on the Series 20.

2.2 FRONT PANEL

The Series 20's front panel is illustrated in figure 2.1. The key numbers refer to the text following the figure.

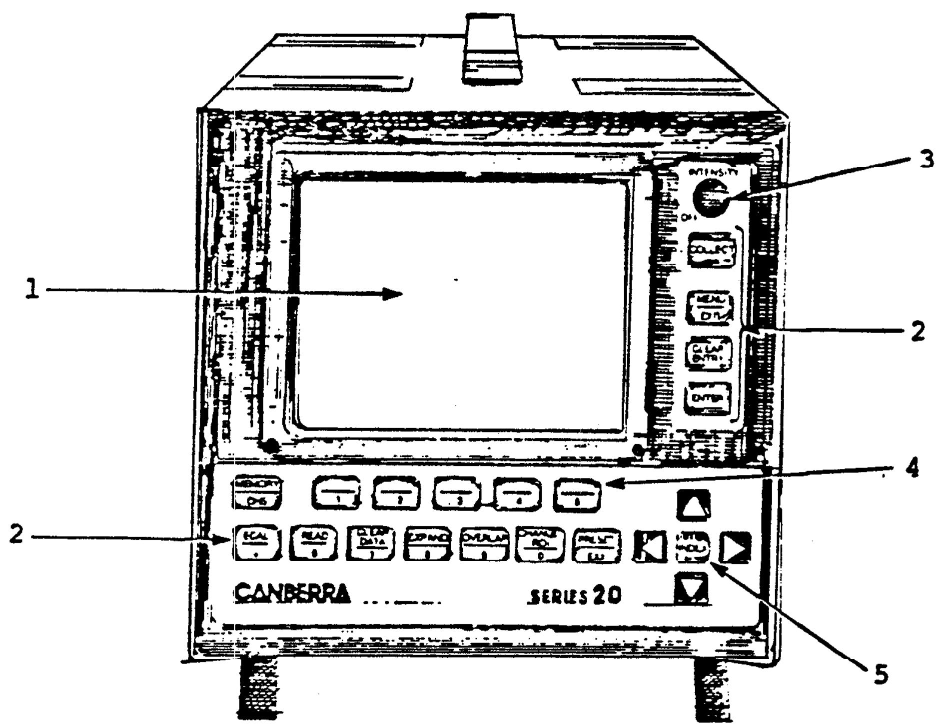


Figure 2.1 Front Panel

1. The display is an 18 cm CRT screen (measured diagonally).

2. Below the display and to its right are a number of keys. Most of the keys are labeled with two functions. These are called hard keys.

3. The INTENSITY control varies the display's brightness for comfortable viewing. The control also turns the Series 20 ON and initializes the unit when it is turned clockwise.

4. The numeric keys 1 through 5, are called soft keys; their labels, shown on the display's bottom line, change with the function being defined.

5. The INDEX key in the lower right corner of the front panel moves the cursor to the start of the next ROI, if any, otherwise it has no function. The two horizontal arrow keys control cursor movement. The two vertical arrows control the display's Vertical Full Scale and some parameter entries.

2.3 HARD AND SOFT KEYS

The Series 20 uses two types of function key: the "hard" key and the "soft" key. Pressing the MENU/EXIT hard key (one with a permanently defined function) to the right of the display will show a line of soft keys (keys with changeable function definitions) at the bottom of the screen.

Soft key labels are automatically displayed on the line above the first five numeric keys. These key labels change according to the current function.

A hard key function is activated by pressing its key. A soft key function is activated by pressing the numeric key just below the appropriate label.

In this manual the hard keys are shown in boldface type in a box outline.

[COLLECT]

The soft keys are shown with the function name enclosed in a dashed outline.

(STATUS)

2.4 INITIAL DISPLAY

A few seconds after the power is applied, the display in figure 2.2 will appear on the screen.

```
    (1)                    (2)                      (3)
-----------------------------------------------------------------
    CL= 0                  MEM  1/1                 FROM   2    TO 4095
    CTS= 0                 VFS  64                  INTG= 0




    STATUS     COMPUTE    EXECUTE                   PSET(L)= 1000
    PAGE       TIME       TASK S1                   ELAP(L)= 0
-----------------------------------------------------------------
    (4)        (5)        (6)                       (7)
```

Figure 2.2 Initial Display

1. CL = the Cursor's Location in the spectrum.
   CTS = the COUNTS at the cursor's location.
   ROI# = current ROI number, if any, otherwise not shown.

2. MEM = current memory group.
   VFS = the display's Vertical Full Scale.
   Status = Series 20's current status; if idle, nothing is shown.

3. FROM-TO = low and high channels of current ROI, if any, otherwise of display's current limits.
   INTG* = Integral (total number of counts) in the current ROI, if any, otherwise of the channels in the current display.
   AREA* = Integral minus the averaged background of the current ROI, if any, otherwise not shown.

4. STATUS PAGE. A permanent soft key which causes display of the Series 20's current parameters. Figure 2.3 shows you an example of what you'll see when you press this soft key.

5. COMPUTE TIME. A permanent soft key which causes display of last start-of-collect time. In the Model 2802, can also start the last enabled COMPUTE equation (COMPUTE FUNC n [or AP-PAK n]).

6. EXECUTE TASK. A permanent soft key which causes execution of last defined or used Task Sequence. In the Model 2801, this is a Recycle Task.

7. PSET (A) = preset on PHA Area
   PSET (C) = preset on PHA Counts
   PSET (F) = preset on PHA Function
   PSET (I) = preset on PHA Integral
   PSET (L) = preset on PHA Live time
   PSET (S) = preset on MCS sweeps
   PSET (T) = preset on PHA True time
   ELAP ( ) = elapsed preset.

8. COMMAND LINE. In Menu dialog, the second line above the bottom of the display is the Command Line. It shows dialog prompts and current parameters.

9. SOFTKEY/ERROR LINE. In Menu dialog, the display's bottom line is the Soft Key Line. It displays all soft key labels. It also displays an error message if you issue an incorrect command.

---

*The Series 20 calculates and displays the Integral of the current Region of Interest (ROI), if any, otherwise of the displayed memory segment. Current ROI is the one containing the cursor; if the cursor is not in an ROI, the current ROI is the one to the right of the cursor. Integral and Area calculations are included in all readouts.

Integral	The Integral is the summation of the number of counts in each channel considered. The algorithm is given in appendix H.
Area	The Area of an ROI is its Integral minus its background. The algorithm is given in appendix H.
Overlapping ROIs	If overlapping ROIs have been entered, the cursor must be in a channel higher than the lower ROI's stop channel in order to calculate the higher ROI's Area and Integral.

2.5 STATUS PAGE

If you press the STATUS PAGE soft key (the numeral 1), the display will change to show a list of the current data acquisition and EIA parameters. If you want to see the current calibration parameters (the calibration equation), press the ECAL key.

Figure 2.3 shows the Status Page with the default parameters. The Model 2801 parameters are shown in parentheses. The Status Page always shows the last parameter values entered. The clock and calendar show the current time and date; they are not reset by power off.

CANBERRA SERIES 20 V2802-00 (V2801-00)

PRESET LIVETIME= 1000 SECONDS

MODE: IDLE TAGWORD= 0

CURRENT COMPUTE FUNCTION
F1= shown on Model 2802 only

AMP	SCA	ADC	EIA	CLOCK
GAIN 3.5000	LLD 0.000%	GAIN 4096 (2048)	BAUD 300	DA/MO/YR 01/01/84
INPUT POS	ULD 110.0%	PHA ADD	LENGTH 7	TIME 12:45
SHAPING SLOW		OFFSET 0	PARITY EVEN	
		ZERO 0%	STOPBIT 1	CONTROL LOCAL

[AMP] [SCA] [ADC] [EIA] [CLOCK]

Figure 2.3 The Status Page

2.6 SETTING THE CLOCK

After the Series 20's power is turned on for the first time, the usual first step is to set the clock. This procedure will demonstrate the use of the Series 20's Menu.

The Series 20's internal clock is battery powered; once it is correctly set it doesn't need to be reset unless the MCA is not used for long periods or unless the time or the date is to be changed.

1. Press the STATUS PAGE key (the numeral 1 key) at the bottom of the display. The display will change to show the Status Page (figure 2.3). At the bottom of the page is a line of soft keys:

   (AMP) (SCA) (ADC) (EIA) (CLOCK)

2. Press the key under the CLOCK label to see:

   CLOCK
   TIME DATE

3. Press the TIME key. You'll see:

   CLOCK TIME IS
   ENTER HOURS (0-23)

Time is entered one field at a time, first the hours, then the minutes. The Series 20 will wait for a numeric entry between 0 and 23. Use the numeric keys on the front panel to enter the hours on a 24-hour basis. (Don't enter leading zeros.)

For instance, if the current time is 1:30 pm, press [1], then [3]. The Command Line, the line above the Soft Key Line, will show:

CLOCK TIME IS 13
ENTER HOURS (0-23)

Press ENTER to enter the 13 into the memory. Now you'll see:

CLOCK TIME IS 13:
ENTER MINUTES (0-59)

correcting errors

Now you can enter the minutes. Make a deliberate mistake here and enter "20" minutes instead of "30". To clear this incorrect entry, press

[CLEAR ENTRY]

This erases the minutes field. Now you can enter the correct minutes, "30". You'll see:

```
CLOCK TIME IS 13:30
ENTER MINUTES (0-59)
```

Press ENTER to transfer the minutes. The correct time will now be seen on the Status Page. ENTERing the minutes sets the clock to zero seconds. Use this ENTER to synchronize the internal clock to an external clock.

If you're not going to make any further changes, you can end the SETUP mode by pressing MENU/EXIT. Or you can stay in the STATUS PAGE and select another function from the displayed soft keys.

(AMP) (SCA) (ADC) (EIA) (CLOCK)

entering the date

Press CLOCK again, then DATE to enter the date. The date is entered in a similar way to the time, in three fields: DA, MO, YR (day, month, year).

2.7 BASIC DIALOGUE RULES

The Series 20's dialog rules, illustrated during the entry of the time and date, are listed in full in this section.

1. To start any function, press a key.
2. Complete the soft key dialog as it appears on the screen, line by line.
3. When a parameter or function is chosen, the display's Command Line will usually show the current value of that parameter or function.

4. The ENTER key is used to enter a numeric entry.

5. If you select a soft key labeled with an octothorp (#), the Series 20 will expect a number to be entered.

6. The CLEAR ENTRY key will cancel any numeric entry or any function key entry. It also clears an error message from the display.

7. If the dialog line has been completed, pressing the CLEAR ENTRY key will let you back up through the Menu, level by level.

8. To leave the dialog at any time, press the MENU/EXIT key. Any parameters chosen or ENTERed so far will have been stored in memory.

2.8 DISPLAY SCALE

The display's Vertical Full Scale (VFS) value is set by the up/down arrows when the Series 20 is not in dialog.

If either arrow key is held down, the display will cycle up or down through all VFS values. The log values are at the "top end" of the linear values.

The linear VFS range is 2^6 to 2^{24}.
In log, the VFS range is either 2^{17} or 2^{24}.

2.9 DISPLAY FUNCTIONS

The Series 20 offers you the ability to alter several display functions:

•Display data as point or line •Double or halve the expanded display scale •Clip or wrap data at maximum vertical full scale •Automatic or manual data scaling

Most users set the display parameters once, as described in section 3.11. There are, however, a few users who will want to frequently alter these parameters.

For these users, the Series 20 includes a unique feature, the OP-KEYS soft key. To activate this key, press these keys in the order shown:

MENU	hard key to the right of the screen
ETC	soft key (the numeral 5 key)
DISPLAY	soft key (the numeral 1 key)

The unlabeled numeral 5 key.

When the numeral 5 key is pressed, its label will change from blank to OP-KEYS and the unmarked front panel display keys will be enabled. The keys are located to the left of and below the display screen as shown in figure 2.4.

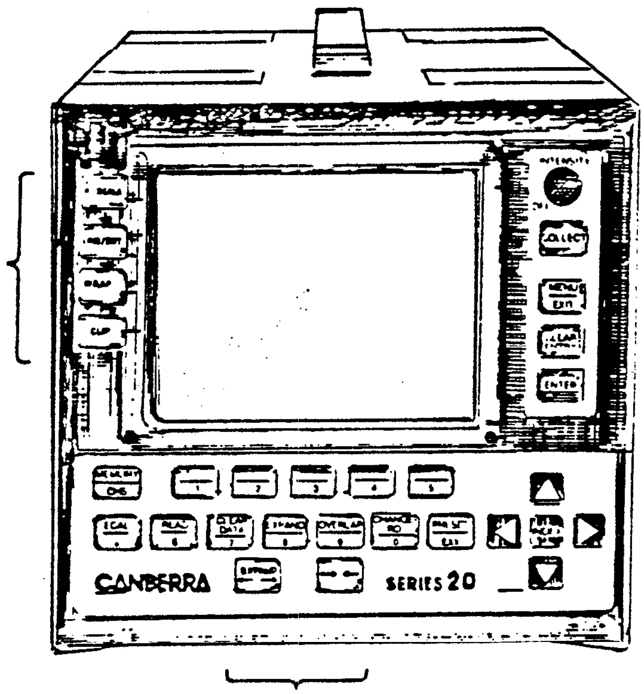


Figure 2.4 Display Key Locations

2.10 INPUT/OUTPUT

Data can be read out of the Series 20 to any EIA device, to the Model 5421M Cassette Recorder, or to a computer. You can read out all data or only ROI data in the current memory group.

The readout will also contain the information on the Status Page, so readin will automatically set the parameters correctly for that data.

Using the 5421M

The Model 5421M Cassette Recorder's volume and tone controls should be set to MAXimum. Gaps are recorded at the beginning and end of Read Out. For a Read In, move the tape to the beginning of the record using the Model 5421M's tape counter. When the readin is finished, verify the Tag number on the STATUS PAGE.

To rewind or advance the tape, pull out the 5421M's REM (center) plug then press REWIND or FAST FORWARD.

2.11 NON-VOLATILE MEMORY

For maximum user convenience, the Series 20 contains an internal nickle-cadmium battery which supplies power to the parameters memory and the system clock/calendar when the ac line (mains) power is off. The battery will keep the parameters memory alive for at least 2 weeks when the ac power is off.

The battery receives a continuous charging current when ac power is on, so you can be assured of a fully charged battery when the power is removed.

Another internal battery, the optional Model 2883 Data Saver, will keep the data memory alive for 8 to 12 hours when ac power is removed.

2.12 DATA ID

Another useful feature built into the Series 20 is the ability to identify a data collection sequence.

This can be done by pressing READ, IN, and EIA. Then on an EIA terminal's keyboard:
1) Hold down CTRL and type B;
2) Type no less than 24 characters and spaces.

More than 24 characters will be ignored, so fill the field with spaces, if necessary. Press READ and STOP on the Series 20 to leave the readin mode.

Turning power OFF will set the Data ID to its default (Series 20). When a spectrum is read in from tape, the Data ID will be changed to the one recorded with the spectrum.

2.13 DATA MANIPULATION

Section 1 covered the procedure for you to follow to collect a data spectrum. This section uses the spectrum to introduce you to some of the data manipulation features of the Series 20.

1. To move the cursor, press the left or right arrow on either side of the INDEX key. The cursor will move in the direction of the pressed arrow.

2. Move the cursor to the left side of a spectral peak, then enter a Region of Interest (ROI) around the peak. The peak's data points will be intensified to show that they are in an ROI.

a. Press the CHANGE ROI hard key.
b. Move the cursor to the peak's left side.
c. Select CREATE and press ENTER.
d. Select CURSOR and press ENTER.
e. Scan the cursor through the peak.
f. At the end of the peak press ENTER again.

3. A Region of Interest (ROI) has now been entered around the peak.

4. Repeat steps 'b' through 'f' for several more peaks.

5. Press MENU/EXIT to end the ROI function.

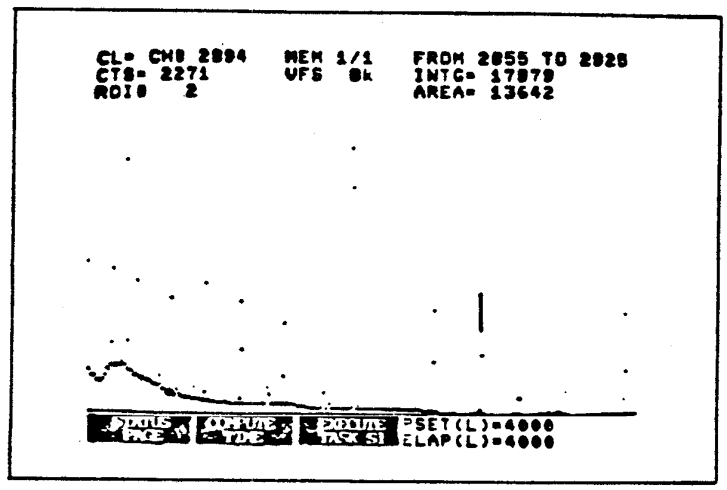


Figure 2.5
Display with ROIs

6. Press INDEX and watch the cursor jump from the beginning of one ROI to the beginning of the next. INDEX will also move the cursor from the last ROI in the spectrum to the first one.

7. Press EXPAND to see the display change to include only 512 channels. The cursor can be moved within the expanded data window. When the cursor approaches either side of the window, the window will begin to move through the spectrum.

8. Press EXPAND again to disable the function.

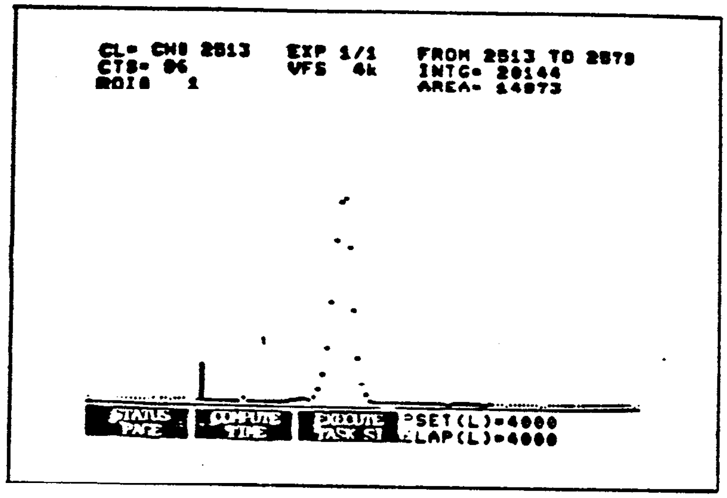


Figure 2.6
EXPAND Display

9. Press MEMORY, then the HALF key.

10. Press the numeral one to select the first half. The display will change to show only the first half of memory.

11. Press OVERLAP, then select 2. The data in the second half of the memory is now shown above the data in the first half. This function is useful for comparing two spectra.

12. Press OVERLAP again to disable the function.

13. Press CLEAR DATA and select DATA. All data has now been cleared from the display. This function clears only the memory section selected by the MEMORY key; other sections are not affected.

14. Press MEMORY and select FULL. The display now shows the data contained in the entire memory. Since the first memory half was cleared in step 13, it is empty of data. The second memory half still contains data.

15. Press CLEAR DATA and select DATA. The entire memory is now cleared.

2.14 MCS MODE

MCS data acquisition uses nearly the same setup as for the PHA experiment in section 1, except that you'll have to program the Series 20 for MCS instead of PHA.

1. Press STATUS PAGE, then press ADC. Now select MCS, then ADD. The Status Page will be updated to show each choice as it is made.

2. The default preset parameters for MCS will give you only one sweep through memory. In order to see more MCS data, you'll have to change the preset.

3. Press PRESET. You'll see the current preset parameters. Press ETC, then select SWEEP. Assign 100 to sweeps and press ENTER.

4. With the sample near the detector's face, press COLLECT. MCS data acquisition will start and will continue until 100 sweeps have been recorded.

As data collection proceeds, you'll see the type of spectrum resulting from this different acquisition mode. Figure 2.7 shows an MCS spectrum.

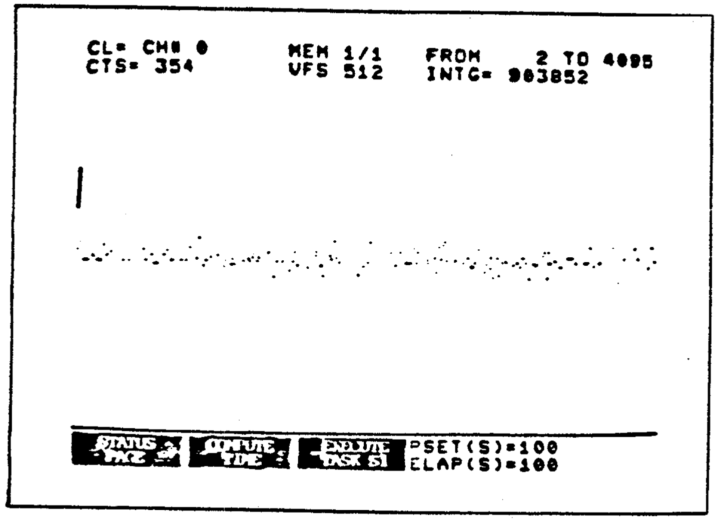


Figure 2.7
MCS Display

2.15 System Reset

In the unlikely event that the analyzer should stop operating normally, simply turn the front panel INTENSITY control OFF for a few seconds and back ON. This will return the Series 20's program to a known state so that it can continue normal operation.

If you suspect that the Series 20 is not operating correctly, you can use any of the built-in self tests to verify the fault. Refer to section 3.10.

This section lists all of the Series 20's hard and soft keys alphabetically. The left-hand page describes the function and its uses. The right-hand page tells how to access and perform the function.

The only exceptions to the alphabetic listing are the RECYCLE function, covered in section 3.14, Execute, and the five hard keys and four arrow keys to the right of the display, which are described here.

COLLECT The COLLECT key starts and stops data acquisition using the STATUS PAGE parameters.

For best performance, the rear panel pole/zero (P/Z) control should be properly adjusted for the amplifier parameters and preamplifier used. You can find the procedure in appendix F.

If the current memory group is in active Read, Collect will start when Read ends. When PHA Collect ends, the elapsed Live time and True Time will be placed in channels 0 and 1, respectively.

If a sample changer is attached (appendix L), data acquistion will not start until it is in counting position.

MENU/EXIT The MENU/EXIT key enters or exits the Menu dialog tree.

CLEAR ENTRY The CLEAR ENTRY key erases the current parameter field before it is ENTERed, clears an error, or backs up through the Menu tree.

ENTER The ENTER key enters a numeric parameter while in dialog.

INDEX The INDEX key moves the cursor to the start channel of the next Region of Interest (ROI), if any. Otherwise it has no function.

ARROWS The left and right arrows control cursor movement. Holding either arrow down will move the cursor in the direction of the arrow at an accelerating rate.

The up and down arrows control some Status Page parameters and the display's vertical full scale (VFS). If you're not in the menu, holding down either of these arrows will move the display through all VFS values:

The linear VFS range is 2^6 to 2^{24};
the log VFS range is either 2^{17} or 2^{24}.

3.1 ADC

Sets the ADC parameters.

ZERO*

ZERO shifts the ADC zero relative to zero volts input. The range is 0 ± 5% of the ADC's full scale input, in steps of 0.04%. For greatest accuracy it should be reset whenever the ADC Gain is changed, but it is not critical. You can find the procedure in appendix G.

OFFSET

OFFSET relates memory channel zero to ADC channel conversions. The range is 0 to 4000 channels, in multiples of 4. The effect is to shift the spectrum by the selected number of channels.

GAIN

GAIN sets the ADC's full-scale resolution; that is, the number of parts that the full-scale input is divided into. The higher the gain, the smaller the voltage increment between channels and the better the resolution. You have a choice of four gains.

PHA

PHA selects the Pulse Height Analysis Mode of data collection. Stores inputs within the SCA limits.

MCS

MCS selects the Multichannel Scaling Mode of data collection. Stores inputs within the SCA limits.

ADD

ADD adds incoming data to the data already in memory.

SUB

SUB subtracts incoming data from the data already in memory.

---

*The ADC ZERO is set using a Digital to Analog Converter. Although the dialog will allow any number within the parameter's range to be entered, the Converter will use the nearest value within its resolution.

Because of this, you may find that the value used by the Series 20 is not exactly the same as the value you entered.

approach	(STATUS PAGE) (ADC)
choose	(ZERO) (OFFSET) (GAIN) (PHA) (MCS)
ZERO	Assign a number (0 ± 5% of the ADC's full scale input) and press ENTER.
OFFSET	Assign a number between 0 and 4000 and press ENTER.
GAIN, choose one	(512) (1024) (2048) (4096) (4096 is not available on the Model 2801.)
PHA or MCS, choose	(ADD) (SUB)

3.2 AMP

POS/NEG

Sets the amplifier's input polarity to match the external preamplifier's output signal polarity.

FAST/SLOW

Sets the shaping time-constant to FAST for Sodium Iodide detectors or SLOW for Germanium detectors.

GAIN*

Gain places the radioisotope peaks higher or lower (right or left) in the display.

You will see the current amp gain setting and you will be offered the choice of COLLECT or a number entry (#).

Pressing the COLLECT soft key at any point in the amp dialog will clear data and start collect so that you can see the effect of the changes. Note that this Collect shows 100% on the dead time meter because it does not record Live Time.

To change the gain, use the up/down arrows or press (#), enter a number between 3.5 and 1230, then press ENTER.

Now press the COLLECT soft key and use the front panel UP/DOWN arrows to slowly change the displayed gain. It will be easier to see the changes if you press the COLLECT soft key occasionally to clear the display.

For optimum performance, the rear panel pole/zero (P/Z) control should be properly adjusted for the amplifier parameters and preamplifier used. You can find the procedure in appendix F.

---

*Amplifier GAIN is set using a Digital to Analog Converter. Although the dialog will allow any number within the parameter's range to be entered, the Converter will use the nearest value within its resolution.

Because of this, you may find that the value used by the Series 20 is not exactly the same as the value you entered and you may not be able to put a peak in the exact channel desired. The Gain D/A is stable and repeatable, but not monotonic.

approach	(STATUS PAGE) (AMP)
choose	(POS) (NEG) (FAST) (SLOW) (GAIN)
POS/NEG/FAST/SLOW	No further action needed.
GAIN	(COLLECT) (#)
(#)	Press the (#) key, assign a number between 3.5 and 1230 for the gain setting, then press ENTER.
COLLECT	Press the COLLECT soft key to see the effect of gain changes.
	Use the UP/DOWN arrows to make fine adjustments in the Gain. It helps to press the COLLECT soft key after each adjustment to clear data and restart collect.

3.3 ANALYZE (Model 2802 only)

Analyze lets you define up to 5 Functions (equations) or learn or execute up to 5 Sequences (tasks).

DEFINE	Define is covered in section 3.9. All of the default equations and several other useful equations are listed in appendix I.
LEARN	Learn is covered in section 3.16.
EXECUTE	Execute is covered in section 3.14.
SAVE	SAVE reads out a binary-encoded record of any defined Sequence or all 5 Functions (defined or not) to a Model 5421M Cassette Recorder (TAPE) or to any EIA recording device for future use.
LOAD	LOAD reads in a saved Sequence or all Functions from a Model 5421M Cassette Recorder (TAPE) or any EIA device on which the record was made. A recorded TAG number will be read back in; it can be seen by enabling the STATUS PAGE.
predefined equations	The Model 2802 includes a set of Ratio equations and a Percent Error equation (listed in appendix I). These equations are in the parameters memory, but may be cleared and others entered in their place. The Series 20 will save the last defined set each time the power is turned off. When power is turned on again, these equations will be ready to use.

Available in Model 2802 only.

approach	[MENU] (ANALYZE)
choose	(DEFINE) (LEARN) (EXECUTE) (SAVE) (LOAD)
DEFINE	See section 3.9.
LEARN	See section 3.16.
EXECUTE	See section 3.14.
SAVE or LOAD	(SEQUENCE) (FUNCTION)
SEQUENCE only	(S1) (S2) (S3) (S4) (S5)
SEQUENCE or FUNCTIONS	(EIA) (TAPE)
SAVE only	Enter a Tag Number if desired, and press ENTER.

3.4 CHANGE ROI

This function enters or deletes Regions of Interest (ROIs), which are used to mark parts of the spectrum for later analysis and readout. All ROIs in the display are brighter than the rest of the spectrum.

You will number the ROIs as they are entered; these numbers can be refered to in other dialog and for readout. Instead of assigning a number, pressing ENTER will use the next available number in the list.

ROIs can be erased by using DELETE or by creating another ROI with the same number.

An ROI can be entered by choosing CURSOR then moving the cursor through the channels to be in the ROI. Every channel that the cursor moves through will be brightened to show that it is part of the ROI.

Another way to enter an ROI is to choose (#) then enter the start and stop channel numbers for the ROI.

Up to 50 ROIs can be entered and any number can be overlapped.

Current ROI

The display shows the current ROI's number and its start and stop addresses. The current ROI is the one containing the cursor, otherwise it is the next ROI to the cursor's right.

LIST

Displays the ROI list, which shows the defined ROIs by number with their start and stop channel numbers referred to the full memory (for instance: an ROI from channels 68 to 108 in the second half of a 4K memory is listed as 2116, 2156).

SPECTRUM

Changes the list display to the spectrum display while staying in the CHANGE ROI dialog.

INDEX

The front panel INDEX key moves the cursor to the start channel of each ROI in turn moving from display-left to display-right. It will also move the cursor from the right-most ROI in the display to the left-most one. INDEXing to the first channel of a second or greater overlapped ROI can be done by moving the cursor past the last channel of the next lower ROI.

approach	[CHANGE ROI]
choose	(CREATE) (DELETE) (LIST) (SPECTRUM)
LIST/SPECTRUM	No further action is needed.
CREATE	Press ENTER to accept the next available ROI number, or assign a number (1 to 50), then press ENTER.
now choose	(CURSOR) (#)
if CURSOR	Enter the Region Of Interest with the cursor by following the on-screen dialog.
if (#)	Enter the first channel and press ENTER. Then enter the last channel and press ENTER.
DELETE, choose	(ALL) (#)
if ALL	Deletes all ROIs in the memory.
if (#)	Enter the number of the ROI to be deleted.

3.5 CLEAR DATA

The CLEAR DATA key is used to clear (erase) the currently selected memory segment.

DATA — CLEAR DATA clears both data and PHA time or MCS sweeps.

TIME — CLEAR TIME clears just the PHA time counters or the MCS sweep counter. Data channels are not affected.

Note — Using CLEAR DATA while in active Collect may result in incorrect data.

approach	[CLEAR DATA]
choose	(DATA) (TIME)
DATA	Both the data and the time channels in the currently selected memory segment are cleared.
TIME	Only the Live and True time counters are cleared in the currently selected PHA memory segment, not data channels. In the MCS mode, this key clears the sweep counter.

3.6 CLOCK

Used to set the Series 20's internal clock and calendar to current values.

The clock and calendar will continue to update even with the ac power off, as long as the Series 20's internal battery is supplying power.

synchronizing clocks

If you are synchronizing the internal clock to an external clock, ENTERing the minutes sets the clock to zero seconds.

approach	(STATUS PAGE) (CLOCK)
choose	(TIME) (DATE)
TIME	Assign hours (0-23) and press ENTER (don't enter leading zeros). Assign minutes (0-59) and press ENTER (synchronizing point).
DATE	Assign day (1-31) and press ENTER (don't enter leading zeros). Assign month (1-12) and press ENTER. Assign year (0-99) and press ENTER.

3.7 COMPUTE

Compute is used to show time information for the memory segment's collect cycle and, in the Model 2802, to calculate a defined Function.

FUNCTION

In the Model 2802, FUNC will solve a defined function (section 3.9). The solution will be displayed and will be updated as the data changes. The equation and its solution can be read out. To include a Function in the ROI readout, enable the Function immediately after pressing COMPUTE.

OFF

With COMPUTE enabled, OFF will turn off the displayed evaluation, but the Function can still be read out. To omit the function from the readout, go into the Menu again and press COMPUTE, then OFF.

TIME

The TIME key is used to display the start-of-collect time, elapsed Live and True time, and in MCS, elapsed sweeps. The TIME parameter is included in all readouts.

COMPUTE "X" Soft Key

The COMPUTE "X" permanent soft key at the bottom of the normal display will execute the last enabled function number (X = FUNCTION n) or show the current start-of-collect time (X = TIME)

To return "COMPUTE FUNCTION n" to "COMPUTE TIME", press MENU, COMPUTE, and OFF.

AP-PAK/MED-PAK

The Model 2802 Series 20 can include the optional Model 2886 AP-PAK or 2886N MED-PAK. These options contain predefined equations which operate similarly to the FUNCTION sofkey.

The equations are in Read Only Memory (ROM) and can't be changed. However, most of these equations require manual entry of one or more ROIs by way of the CHANGE ROI function (section 3.4) and one or more constant parameters through the DEFINE function (section 3.9). Refer to appendix J for a listing of the 2886's equations and the constants which you have to enter. The 2886N is covered in a separate manual.

approach	[MENU] (COMPUTE)
choose	(FUNC) (OFF) (TIME) (AP-PAK)
FUNC (Model 2802 only)	(F1) (F2) (F3) (F4) (F5) and press ENTER.
OFF	Turns off Function's display and readout or display alone (see OFF on the opposite page).
TIME	No further action is needed.
AP-PAK or MED-PAK	Press this key to enable the PAK's equations.

3.8 DEFAULT

The DEFAULT key returns all parameters to the factory default condition.

The data spectrum, ROI list, memory assignment, data ID, Functions, and Sequences are as last set. The time and date will be current. The default STATUS PAGE is shown below.

Most parameters are common to both models. The parameters which apply only to the Model 2802 are shown in parentheses.

CANBERRA SERIES 20 V2801-00 (V2802-00)

PRESET LIVETIME= 1000 SECONDS

MODE: IDLE TAGWORD= 0

(CURRENT COMPUTE FUNCTION)
(F1=)

AMP	SCA	ADC	EIA	CLOCK
GAIN 3.5000	LLD 0.000%	GAIN 2048 (4096)	BAUD 300	DA/MO/YR 01/01/84
INPUT POS	ULD 110.0%	PHA ADD	LENGTH 7	TIME 12:45
SHAPING SLOW		OFFSET 0	PARITY EVEN	
		ZERO 0%	STOPBIT 1	CONTROL LOCAL

Figure 3.1 Default Status Page

approach

[MENU] (ETC) (DEFAULT) (YES)

YES sets all parameters to their factory default values (see the opposite page).

3.9 DEFINE (Model 2802 only)

Defines up to five Functions (equations) of up to 37 characters each. A Function can be displayed and read out (section 3.7, COMPUTE), or used for a PHA preset (section 3.19, PRESET). See appendix I for default/other equations.

Function Chaining — Any Function can include the results of a higher numbered Function at any point in its calculations; use FUNC.

END — END ends the equation definition.

CLEAR — CLEAR ALL erases the current equation. CLEAR ONE corrects an error by erasing the equation's last displayed step.

CONTINUE — CONTINUE allows you to define the Function using the 10 digits and the decimal point (.), CHS (change sign), and EEX (base 10 exponent) keys on the front panel, and any of the terms shown under CONTINUE, which are defined as:

CL	(C)	Cursor's channel number at the time of equation evaluation.
CNTS@CL	(@C)	Cursor location counts at the time of equation evaluation.
INTEG/AREA	(I/A)	Integral or Area of an ROI (enter the ROI number).
#		Enters numeric entries into a Function.
* / + -		Arithmetic operators. The * and / are evaluated 1st; + and - evaluated 2nd. Within each rank, evaluated left to right.
( )		Parentheses set order of calculation; performed left to right
LIVETIME/ TRUETIME	(LT/TT)	Value of Live (LT) or True (TT) Time in fractional seconds (resolution ≈ 0.015 s).
FUNC	(Fn)	Use the results of equation Fn (enter the Function number). Fn must be higher than the current number.
@LOW	(@Ln)	Low channel counts of an ROI (enter the ROI number).
@HIGH	(@Hn)	High channel counts of an ROI (enter the ROI number).
@#	(@n)	Counts in channel "n"* (enter the channel number).
LOW	(Ln)	Number of lowest ROI channel* (enter the ROI number).
HIGH	(Hn)	Number of highest ROI channel* (enter the ROI number).
EXP	[EXP( ]	Takes the natural log e of the following expression (enter the expression; follow it with a closing parenthesis).
SQR	[SQR( ]	Takes the square root of the following expression (enter the expression; follow it with a closing parenthesis).

---

*Channels are numbered as if FULL memory were selected.

Available in Model 2802 only.

approach	[MENU] (ANALYZE) (DEFINE)
choose	(F1) (F2) (F3) (F4) (F5) Displays current equation.
choose	(END) (CLEAR) (CONTINUE)
END	Accepts the equation; no further action is needed
CLEAR choose one	(ALL) (ONE)
CONTINUE choose one at a time	(CURSOR) (INTEG) (AREA) (#) (ETC) (*) (/) (+) (-) (ETC) ([ ) ( ]) (LIVETIME) (TRUETIME) (ETC) (FUNC) (@) (LOW) (HIGH) (ETC) (EXP) (SQR) (ETC)
finally	When the equation has been defined, press END to exit the dialog.
note	In the display, ROI 0 means the current ROI at the time the calculation is done. That is, the ROI that the cursor is in, or if the cursor is not in an ROI, the next one to the right of the cursor. In readout, ROI 0 means that the equation will be calculated for each ROI as it is being read out. If a specific ROI number is assigned, the calculation will be done only for that ROI, with the results of this one ROI calculation being reported for all ROIs.

approach	[MENU] (ETC) (DIAGNOSE)
choose	(PROM) (RAM) (ADC) (SCA) (EIA/FSK)
ADC, SCA, or EIA/FSK	(STOP) stops test at the end of the current cycle.

REFERENCE

See appendix B for details.

3.11 DISPLAY

The DISPLAY key allows you to choose various display functions. For the majority of users, the display parameters are set once and not altered. But for users who want to be able to vary the parameters at will, the OP-KEYS soft key enables the unmarked front panel display keys.

A-SCALE

The Auto-Scale key automatically sets the displayed data for the correct vertical full scale. Pushing either the up or down arrow will disable autoscale.

LINE/DOT

This key toggles the display between a spectrum of unconnected dots and a continuous-line spectrum.

WRAP

The Wrap mode causes additional data beyond the VFS setting to increase from the bottom of the screen.

CLIP

The Clip mode causes additional data beyond the VFS setting to be "cut off" at the top of the screen.

OP-KEYS

Press the number 5 key to see the OP-KEYS label and enable the unmarked front panel DISPLAY and EXPAND keys. Refer to figure 3.2 for display key locations.

Expand/Reduce Window

The ← → key expands the displayed window by a factor of 2 so that half as many channels are seen. The → ← key reduces the displayed window by a factor of 2 so that twice as many channels are seen.

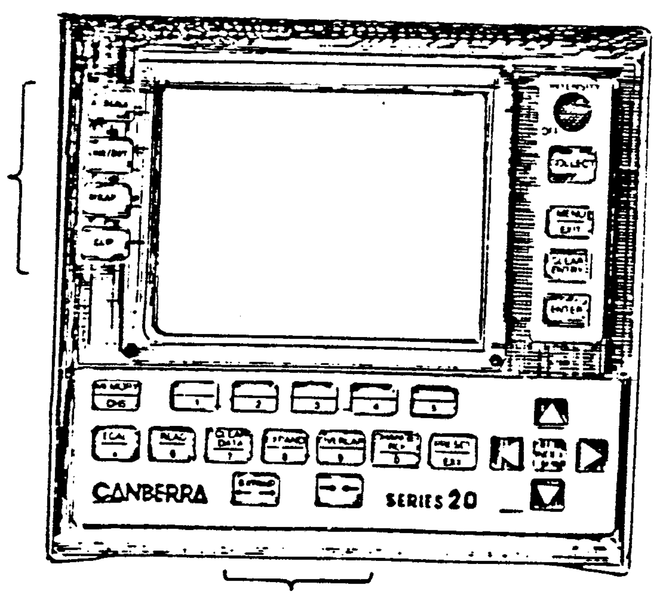


Figure 3.2 Display Key Locations

approach	[MENU] (ETC) (DISPLAY)
choose	(A-SCALE) (LINE/DOT) (WRAP) (CLIP) (OP-KEYS)

3.12 ECAL

Calibrates a PHA spectrum in energy units or an MCS spectrum in time units. In a calibrated spectrum, the cursor location will be shown as calibration units instead of as a channel number, which helps you to identify an unknown radioisotope.

The Series 20 uses a first order (straight line) equation, so you will have to enter two known energy points (for example, from a radioisotope standard), one at each end of the spectrum, to define the line. For a better definition, enter more than two points.

The equation is used for all displayed or read out segments of the memory. Since cursor location and channels are numbered relative to the displayed memory segment, a spectrum can be collected in one quarter and transferred to or overlapped with another quarter with the ECAL or channel readout being the same. If a spectrum is viewed with a smaller memory segment than it was collected in, the ECAL readout may not be correct.

When you press ECAL you will see the current calibration equation on the Command Line. You can accept the old equation or enter a new one.

UNITS

The UNITS key selects the calibration units.

FIT

The FIT key assigns calibration values to specified channel addresses.

CLEAR

The CLEAR key clears the old equation from memory.

OFF

The OFF key turns off the calibration equation. Channel addresses will be shown as numbers, counting from the beginning of the current memory segment.

Changing Units

After the calibration is made, you can re-enter the dialog to select a different calibration unit. The display's CL= line will automatically show the correct value using the new calibration unit.

Adding Points

If you find that the calibration is not quite correct at some known point in the spectrum, go into the FIT dialog again and add one or more points. The more points you enter, the better the equation's fit.

Calibrated Read Out

If you enable ECAL before READ OUT, the equation will be read out to one decimal place. All channel addresses will be reported in calibration units.

approach	[ECAL]	Displays the current calibration.
use current	To use the current equation, press the MENU/EXIT key	
or choose	(OFF) (UNITS) (FIT) (CLEAR)	
OFF	Turns ECAL equation off and changes the cursor address from units to channel numbers; the equation remains in memory. Press MENU/EXIT to leave the dialog.	
CLEAR	Press the YES key to erase the old calibration from the memory.	
UNITS	(ENERGY) (TIME)	
if energy, choose	(eV) (keV) (MeV)	
if time, choose	(us) (ms) (sec)	
	The dialog will return to the first ECAL line.	
FIT	Choose (CURSOR) (#)	
if cursor	Press ENTER to assign cursor's current channel number.	
or if (#)	Assign a channel number and press ENTER.	
then	Assign the calibration value and press ENTER.	
use equation	After entering at least two calibration points, press the MENU/EXIT key to leave the dialog.	

3.13 EIA

Sets the EIA's output for:

- Baud Rate - 110 to 19,200
- Character Length - 7 or 8
- Parity - off, even, or odd
- Stop Bits - 1 or 2
- Control - Remote or Local

Baud, Length Parity, Stop Bits

The first four parameters must be set to match the needs of the EIA device being used. You will find the device's parameters listed in its operating manual. Note that the Computer (READ, section 3.20) and Save/Load (ANALYZE, section 3.3) formats require an 8-bit character length.

Control

With the Model 2884 PC Interface, the Control parameter switches the Series 20 EIA interface between LOCAL (I/O to a printer or terminal) and REMOTE (computer controls the Series 20). When the Remote mode is enabled, only the 2884's I/O is done; no other I/O can be done until the Series 20 is returned to LOCAL control. Refer to the Model 2884 PC Interface manual.

EIA Connector

The EIA connector interfaces the Series 20, as a modem emulator, directly to EIA terminals. The EIA interface provides for both hardware and software (XON/XOFF) handshaking. Refer to appendix C for EIA I/O format and to appendix E for EIA connector signals.

Cassette Connector

The CASSETTE connector is an FSK analog circuit port designed for compatibility with the Model 5421M Cassette Recorder only; its parameters cannot be changed.

approach	(STATUS PAGE) (EIA)
choose	(BAUD) (LENGTH) (PARITY) (STOPBIT) (CONTROL)
BAUD, choose	(0)=110 (1)=300 (2)=600 (3)=1200 (4)=1800 (5)=2400 (6)=3600 (7)=4800 (8)=9600 (9)=19200
LENGTH, choose	(7) (8)
PARITY, choose	(OFF) (EVEN) (ODD)
STOPBIT	Keypress toggles between 1 and 2 Stop Bits
CONTROL, choose	(REMOTE) (LOCAL) (Remote requires the Model 2884 PC Interface)

3.14 EXECUTE

Execute performs a previously learned Sequence. For the Model 2802, see section 3.16, Learn. For the Model 2801, refer to the Recycle paragraph at the bottom of this page.

sequence cycling

The Sequence's execution can be repeated a specified number of times (cycles). If the Sequence's last step is EXECUTE S"n", where "n" equals the current or earlier executed Sequence number, the Sequence will continue cycling until Stopped or Aborted.

During execution, the display shows each step in the sequence. When a step is one that takes time, such as collect or read out, the next step will be displayed but may not become active until the preceding step is finished.

available keys

During execution, the INDEX, ENTER, CLEAR ENTRY, STOP, ABORT, and Arrow keys are available to you; all other keys are locked out.

EXECUTE
number of cycles

EXECUTE starts performance of a defined Sequence and lets you specify how many times it is to be repeated if the Sequence does not chain to other Sequences.

If zero (0) is entered for the number of cycles to be executed, the Sequence will not be executed. But this enables the EXECUTE Sn permanent soft key for execution of this Sequence.

STOP

STOP followed by ENTER ends a Sequence when its current cycle finishes.

ABORT

ABORT followed by ENTER ends the current Sequence immediately.

EXECUTE Sn Soft Key

In the Model 2802, the EXECUTE Sn permanent soft key (at the bottom of the normal display) will perform a single cycle of the last enabled Sequence (Sn).

Recycle

In the Model 2801, the EXECUTE S1 soft key will start the built-in Recycle Sequence: CLEAR DATA, COLLECT, and READ ACCEPT. You can assign the number of cycles and can STOP or ABORT the Sequence. The preset and readout parameters must be set through the PRESET and READ dialog before pressing EXECUTE S1.

approach	[MENU] (ANALYZE) (EXECUTE)
choose	(S1) (S2) (S3) (S4) (S5)
now	Assign the number of cycles and press ENTER.
During Execution	(STOP) (ABORT) SEQUENCE Sn
STOP	Terminates the current Sequence at the end of the current cycle. Press ENTER to execute.
ABORT	Terminates the current Sequence immediately. Press ENTER to execute.

3.15 EXPAND

Expand is both a hard, front panel key which enables the function, and a soft Menu key, which sets the degree of expansion. When Expand is enabled, the abbreviation "EXP" appears in place of "MEM =" at the top of the display.

The Expand function is explained in the following paragraphs; the soft key on the opposite page.

The Series 20's spectral display consists of 512 horizontal points, so a full memory must be compressed to fit the display. A 4096 channel memory, for instance, is compressed 8 to 1. This means that the Series 20 divides the memory into 512 groups of 8 channels each and for each group displays only the channel with the most data.

Since not every data point can be displayed, the Series 20 includes an Expand function. This function opens a "window" to show all of the data points you selected in the Menu dialog.

An expanded window of 512 channels is shown as 512 single points.

For windows of 64, 128, or 256 channels, more than one point is displayed for each channel. In the line mode, each channel appears as a vertical bar and in the dot mode as a horizontal line.

The expanded window will begin 50 channels lower than the current cursor location, but not lower than the left end of the current memory segment.

Pressing EXPAND again or changing the current memory segment will disable the function.

Moving the Window

You can move this expanded window through the current memory segment by scanning the cursor to the right or left. When the cursor gets close to the end of the expanded data, the window will start moving in the direction of the Arrow key. This means that the data will appear to move in the direction opposite to the arrow.

Note

The Expand key isn't active while a task is running, but can be set prior to starting task execution.

approach [MENU] (ETC) (EXPAND)

choose (64) (128) (256) (512)

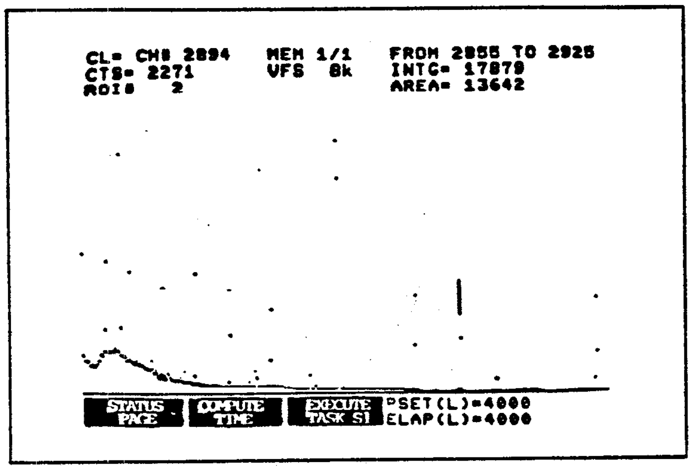


Figure 3.3 Normal Display

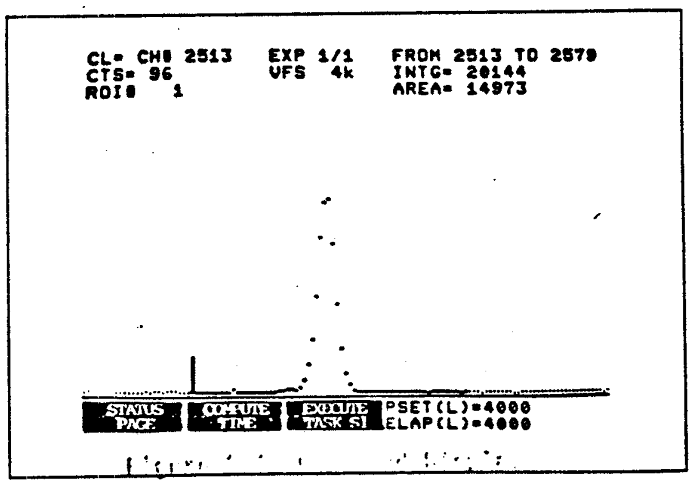


Figure 3.4 Expanded Display

3.14 EXECUTE

Execute performs a previously learned Sequence. For the Model 2802, see section 3.16, Learn. For the Model 2801, refer to Execute Single Cycle at the bottom of this page.

sequence chaining

If the Sequence's last step is EXECUTE S"n", where "n" equals the current or earlier executed Sequence number, the Sequence will continue cycling until Stopped or Aborted.

During execution, the display shows each step in the sequence. When a step is one that takes time, such as collect or read out, the next step will be displayed but may not become active until the preceding step is finished.

available keys

During execution, the INDEX, ENTER, CLEAR ENTRY, STOP, ABORT, and Arrow keys are available to you; all other keys are locked out.

EXECUTE Multiple Cycles

EXECUTE starts performance of a defined Sequence and lets you specify how many times it is to be repeated if the Sequence does not chain to other Sequences.

Entering zero (0) will enable the EXECUTE Sn permanent soft key for Single Cycle execution of this Sequence. This step will not execute the Sequence.

EXECUTE Single Cycle

In the Model 2802, the EXECUTE Sn permanent soft key (at the bottom of the normal display) will perform a single cycle of the last enabled Sequence (Sn). The Single Cycle Sequence can be STOPped or ABORTed.

In the Model 2801, the EXECUTE S1 permanent soft key will start a single cycle of the built in Sequence: CLEAR DATA, COLLECT, and READ ACCEPT. The preset and readout parameters must be set through the PRESET and READ dialog (sections 3.19 and 3.20) before pressing EXECUTE S1.

STOP

STOP followed by ENTER ends a Sequence when its current cycle finishes.

ABORT

ABORT followed by ENTER ends the current Sequence immediately.

Available in Model 2802 only.

approach	[MENU] (ANALYZE) (LEARN)
choose	(S1) (S2) (S3) (S4) (S5)
	If that Sequence is defined, shows the current step. Press soft EXIT and hard ENTER keys to accept the sequence.
now choose	(EDIT) (NEXTLINE) (EXIT) (ABORT) (TOP)
NEXTLINE or TOP	No further action needed.
EXIT or ABORT	Press ENTER to confirm.
EDIT	(INSERT) (CHANGE) (INIT) (END) (DELETE)
CHANGE or INSERT	Press any function key, complete its dialog, and press ENTER. Use the SETUP soft key to learn Status Page parameters.
INIT or END	Press ENTER to confirm.
DELETE	No further action needed.

3.17 MEMORY

Allows you to choose which part of the memory you want to display:

- the full memory
- either half
- any quarter
- any 8th

When choosing halves or quarters, the dialog asks you to choose which half or which quarter to display.

When choosing 8ths, the dialog asks you to assign a number to display that fraction of memory. For instance, entering a 5 will display the fifth 8th of the memory.

approach	[MEMORY] Shows current memory segment.
choose	(FULL) (HALF) (QUARTER) (EIGHTH)
FULL	No further action needed.
HALF, choose	(1) (2)
QUARTER, choose	(1) (2) (3) (4)
EIGHTH	Assign the number of the 8th you want to see.

3.18 OVERLAP

The Overlap function allows you to make a visual comparison between two memory segments of the same size by displaying one segment over another.

You must choose which (same sized) memory segment is to be shown over the current segment.

The lower display trace will be shown in the previously chosen display mode, either "dot" or "line" (see section 3.11). To make it easier to differentiate the two traces, the upper, overlapped, trace will be shown in the other display mode.

The lower trace is the last segment selected by the MEMORY hard key and can be changed to another segment of the same size while in Overlap. The overlapped segments are indicated by "OVL x:x/x" in place of "MEM =" at the top of the display.

For instance, if the display shows OVL 2:3/4, it means that the Second Quarter is shown over the Third Quarter. The 2 means Second, the colon (:) means displayed over, the 3 means Third, and the /4 means Quarter.

The ROIs in the lower trace are mirrored in the upper trace.

When the current display is full memory you can only select FULL.

NOTE

OVERLAP is disabled when learning or executing a task.

approach	[OVERLAP]
	The Command Line shows current memory segment. The next line of dialog displayed depends on the size of the current memory segment.
if FULL	(FULL) (HALF) (QUARTER) (EIGHTH)
	Choose FULL to overlap the full memory over itself. The other choices are not functional.
if HALF, choose	(1) (2)
if QUARTER, choose	(1) (2) (3) (4)
if EIGHTH	Assign the number of the 8th you want to overlap.

3.19 PRESET

Stops data collection when an assigned value (the preset) is reached.

live time — PHA Collect stops after the assigned number of live seconds of collect time have passed.

true time — PHA Collect stops after the assigned number of true seconds of collect time have passed.

area — PHA Collect stops after the Area of a specified ROI equals the preset value.

integral — PHA Collect stops after the Integral of a specified ROI equals the preset value.

counts — PHA Collect stops after the number of counts in a specified channel equals the preset value. Both the number of counts and the channel number must be entered.

function (Model 2802) — PHA Collect stops when the solution of a defined function (F1 through F5) equals the preset value. Both the function's number and its final value must be entered.

mcs sweeps — MCS Collect stops after the number of sweeps equals the preset.

mcs dwell — Sets the time interval for each MCS dwell period. The dwell range is 128 µs to 4.19 s. The actual dwell used may not be the same as your entry because the program will convert the entered number to the nearest multiple of 64 µs. The exact value used can be seen on the STATUS PAGE or, after exiting the PRESET dialog, when PRESET is pressed again.

note — Setting a PHA preset will change the ADC mode to PHA and setting an MCS preset will change the ADC mode to MCS.

approach	[PRESET] Displays current preset.
use current preset	Press the MENU/EXIT key.
or choose	(LIVETM) (TRUETM) (AREA) (INTEG) (ETC) (FUNC) (COUNT) (SWEEP) (DWELL) (ETC) Note: FUNC appears only on the Model 2802.
AREA/INTEG	Assign a value and press ENTER. Now assign a ROI number and press ENTER.
LIVETM/TRUETM SWEEP/DWELL	Assign a value and press ENTER. Values can be entered using exponential notation with the EEX, decimal point (.), and CHS keys.
FUNC	Select a function (F1-F5), assign a value, and press ENTER.
COUNT	Assign the number of counts and press ENTER.
now choose	(CURSOR) (#)
cursor	Selects the current cursor channel.
(#)	Assign a channel number and press ENTER.

3.20 READ

The memory segment displayed while in the READ dialog will be used for data input and output. If it is in active PHA Collect, Read will start when Collect ends. If any memory segment is in active MCS Collect, read in or read out will be executed after MCS Collect ends.

All readouts include the Data ID (section 2.12); tape readouts include the current STATUS PAGE parameters which are read back in with the data. Typical hard-copy readouts are shown in appendix D.

error messages	A faulty readin can cause an "ERR n" message to be displayed. Appendix B.1 explains the error messages.
ACCEPT	Starts I/O using the displayed mode and device.
BKG (2802 only)	Transfers the full 4096 channel foreground memory to the background memory, frees the foreground for more data collection, and reads out the background memory. Note: this sequence doesn't clear foreground memory.
STOP	Stops the current I/O. If in READ IN, a data record must be found before the I/O can stop.
EIA Devices	There are 3 classes of EIA devices: • EIA-ASCII (with control characters); • TERMINAL-ASCII (no control characters); • COMPUTER-binary (data I/O only. For Personal Computer Interface control, see section 3.13). Refer to appendix C for the EIA I/O formats.
Matching Parameters	To make a data transfer you will have to match the Series 20's EIA parameters to the I/O device's EIA parameters. See section 3.13, EIA.
TAPE	Sets the parameters for the 5421M Cassette Recorder.
Tag Number	The Tag Number will be incremented by one each time Collect starts, or another number can be assigned. It is read out/in with the data.
ALL	ALL means read out all data in the memory segment.
ROIS	ROIS means read out the data in each ROI wholly contained in the displayed memory segment. An ROI that starts or ends in another memory segment will be ignored. A hard-copy readout starts with a summary of each ROI; channel data follows.
BRIEF	BRIEF reads out a summary for each ROI, but no data.

approach	[READ] Displays the last used mode and device.
choose	(ACCEPT) (IN) (OUT) (BKG) (STOP)
ACCEPT or STOP	No further action is needed.
IN, choose	(EIA) (TAPE)
BKG or OUT, choose	(EIA) (TERMINAL) (TAPE) (COMPUTER)
now choose	(ALL) (ROIS) (BRIEF) BRIEF doesn't appear for Tape or Computer.
optional	Assign a Tag Number, if desired, and press ENTER

3.21 SCA

Sets or changes the SCA's limits.

LLD/ULD*

LLD means Lower Level Discriminator and ULD means Upper Level Discriminator. These two together set a "window" for conversion of input signal energies to a digital address.

Any inputs that are below the LLD setting or above the ULD setting will not be converted in PHA or counted in MCS.

If you press either LLD or ULD, you will see its current setting in percent of the full scale ADC input. You will be offered the choice of COLLECT or a numeric entry (#).

Pressing the COLLECT soft key at any point in the SCA dialog will clear data and start collect so that you can see the effect of the changes. Note that this Collect shows 100% on the dead time meter because it does not record Live Time.

To change the setting, use the up/down arrows or press (#), enter a number between 0 and 110 (%), and press ENTER.

Now press the COLLECT soft key and use the front panel UP/DOWN arrows to slowly change the displayed setting. It will be easier to see the changes if you press the COLLECT soft key occasionally to clear the display.

---

*The LLD and ULD parameters are set using a Digital to Analog Converter. Although the dialog will allow any number within the parameter's range to be entered, the Converter will use the nearest value within its resolution.

Because of this, you may find that the value used by the Series 20 is not exactly the same as the value you entered.

approach	(STATUS PAGE) (SCA)
choose	(LLD) (ULD)
LLD or ULD	(COLLECT) (#) Press the (#) key and assign a number between 0 and 110 (% of ADC full scale), then press ENTER.
COLLECT	Press the COLLECT soft key to see the effect of the change. Use the UP/DOWN arrows to make fine adjustments in LLD or ULD. It helps to press the COLLECT soft key after each adjustment to clear data and restart collect.

3.22 STRIP

Strip is usually used to subtract a fraction of the data in one memory segment from the data in another segment of the same size. The data, but not the time information, in the first segment will change; the data in the "with" segment will not change.

The factor is the term used to multiply the "with" (reference) segment's data by before stripping it from the data spectrum segment. The factor's range is $\pm 1.17 \times 10^{-38}$ to $\pm 1.677 \times 10^{7}$. The Strip algorithm is in appendix H.

A positive strip factor causes a subtract of one segment from another. If the result is negative, it will be stored as zero.

Using a negative strip factor causes the two segments to be added together.

Normalizing Data

A spectrum can be normalized by stripping a region from itself.

Note

If a segment in active Collect or Read is included as part of the dialog, the Strip will be performed when Collect or Read ends.

approach	[MENU] (STRIP)
choose	(HALF) (QUARTER) (EIGHTH)
	Assign the segment number to be stripped from.
then	Assign the reference memory segment number.
and	Accept the current (displayed) strip factor which the reference memory is to be multiplied by pressing ENTER. Or assign a new factor and press ENTER.

3.23 TRANSFER

Used to copy data from one memory region to another; the data in the "from" region is not erased or changed.

Any two memory segments of the same size can be transferred.

Choose a memory segment, then enter the "from" segment number and the "to" segment number. For instance, to copy data from the first half to the second half, press HALF, 1, 2. When you press the second number, the data will be copied into the "to" segment.

If a segment in active Collect or Read is included as part of the dialog, the Transfer will be performed when Collect or Read ends.

approach	[MENU] (XFER)
choose	(HALF) (QUARTER) (EIGHTH)
then	Assign the "from" segment number.
and	Assign the "to" segment number.

The Series 20's rear panel, illustrated in figure 4.1, carries the power supply's heat sink and a number of connectors. The connectors are listed in table 4.1 and the Signal Input and Gate connectors are discussed in detail in sections 4.1 and 4.2. Appendix E lists the connectors' specifications.

The internal High Voltage Power Supply controls and the display's Dead Time Meter are also covered. Dead Time is discussed in detail in section 5.

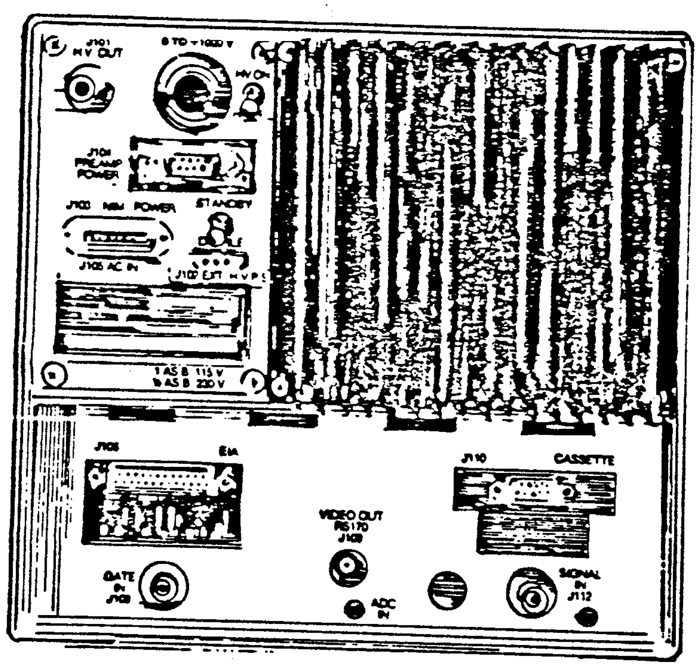


Figure 4.1 Rear Panel

Table 4.1 Rear Panel Connectors

Connector	Description
J101 HV OUT	Supplies the high voltage produced by the internal High Voltage Power Supply. SHV connector.
J102 EXT HVPS	The Model 2861 High Voltage Power Supply is powered from this connector. 3-pin Molex connector.
J103 NIM POWER	Supplies dc power to any NIM module in the optional Model 2882 single-width NIM enclosure. 15-pin D-type connector.
J104 PREAMP POWER	Supplies filtered and regulated ± 12 V and ± 24 V for an associated preamplifier. 9-pin D-type connector.
J105 AC IN	Connector for the ac power line cord. The printed circuit card inside the connector must be set for the correct line supply voltage before power is applied. See section 4.5.
J106 EIA	Data port for any EIA-type I/O device.
J107	Reserved
J108 GATE IN	Receives a logic pulse which conditions the ADC to accept or reject an incoming analog signal. Refer to section 4.2.
J109 VIDEO OUT	Supplies an RS-170 compatible composite video signal to an external monitor or video printer.
J110 CASSETTE	Data port for the Model 5421M Cassette Recorder. (The Model 5421F Cassette Interface is not needed with the Series 20.)
J111	Reserved
J112 SIGNAL IN	Receives the analog input signal from a preamplifier or an external amplifier. Refer to section 4.1.
ADC IN	Test point for looking at the ADC's input signal.
P/Z	Screwdriver-adjustable potentiometer for adjusting the amplifier's pole/zero to compensate for the amplifier's shaping and the external preamplifier's tail pulse. Refer to appendix F for the procedure.

4.1 SIGNAL INPUT

A BNC-type signal connector on the lower part of the rear panel (figure 4.1), labeled SIGNAL IN, is the analog signal input; it accepts the external preamplifier's output signals. This connector can also accept an external amplifier's output signal if jumpers J5, J6, and J7 on the ADC Board are changed from the INT position to the EXT position. The jumpers are accessable through a cutout in the Series 20's bottom cover.

Be sure to keep the signal cables away from the display because it is possible for the display to induce noise on the cables, which will distort the input signals.

4.2 GATE

Another BNC-type connector, labeled GATE IN, accepts logic signals to condition the ADC to either accept or reject input signals for conversion.

The GATE function allows you to enable or disable the ADC for acceptance and conversion of linear signals.

SIGNAL INputs that are time-coincident with the GATE input signal will be converted; others will not.

1. A low logic level (0 to 0.8 V) at the GATE connector will disable the ADC. It will not accept any SIGNAL INputs while the GATE is low.

2. A high logic level (2.5 V to 5.5 V) at the GATE connector will enable the ADC. It will accept and convert all SIGNAL INputs received while the GATE input is high.

   The GATE signal must be high at least from the time of the ADC input's peak amplitude until the input drops by more than 10%.

3. An open (unconnected) GATE input, acts the same as a high GATE input. All SIGNAL INputs will be converted.

4.3 DEAD TIME

Any signal that is present at the input during the time that the ADC is processing a previous signal will be ignored by the ADC. This is because the ADC is busy converting that previous signal and cannot accept another input until finished with the first. This busy time is referred to as the Dead Time.

The Dead Time is shown on the Series 20's display as a bar graph, which is displayed only in the PHA COLLECT mode.

Dead Time is explained in more detail in section 5.4.

4.4 HV ON - HV OFF

The HV ON - HV OFF switch turns the internal positive High Voltage Power Supply (HVPS) on or off. If your detector requires negative polarity high voltage, you'll need an external high voltage source, such as the Model 2861 HVPS, or equivalent.

HV amplitude

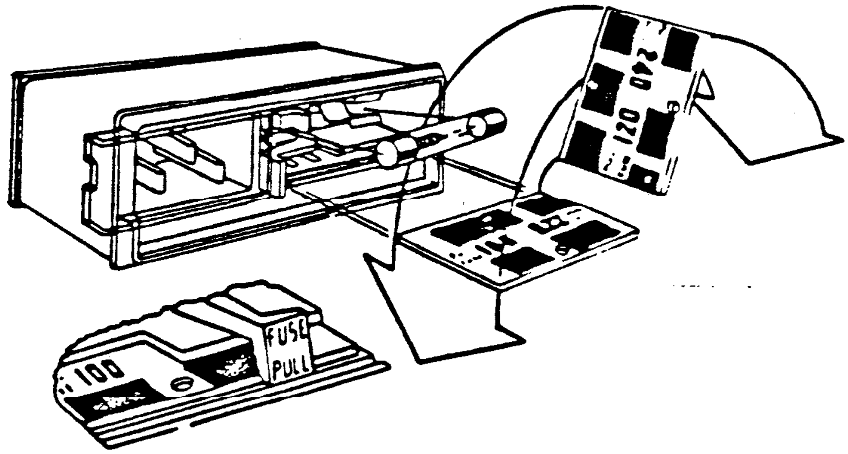
The adjacent ten-turn locking-dial potentiometer sets the HV output's amplitude. Each large number on the dial equals 100 volts; each small number equals 10 volts. For example, setting the dial at large number 5 plus small number 2 will make the HV output equal to 520 volts.

4.5 OPERATING VOLTAGE SELECTION

To change the Series 20's operating voltage, move the plastic fuse cover, next to the ac line cord socket, to one side. The operating voltage setting will be visible just below the fuse.

To change between 120 V and 240 V operation, or to change to low-line operation (100 V or 220 V), carefully pull the small pc board out of its socket (a pair of needle-nose pliers will be helpful here) and replace it so that the desired voltage is visible beneath the fuse. Refer to figure 4.2.

Figure 4.2
Voltage Selection



4.6 FUSING REQUIREMENTS

Each voltage setting has an operating voltage range. Check the fuse for the proper rating, as shown in table 4.2, when changing the voltage setting.

Table 4.2
Fuse Selection

Voltage Setting	Operating Range	Fuse Rating
100	95 V to 105 V	1 A slow-blow
120	105 V to 125 V	1 A slow-blow
220	190 V to 210 V	1/2 A slow-blow
240	210 V to 250 V	1/2 A slow-blow

SECTION 5 SERIES 20 APPLICATIONS AND ARCHITECTURE

From a data acquisition point of view, all Series 20 MCA applications can be placed into one of two categories: Pulse Height Analysis (PHA) or Multichannel Scaling (MCS). This section discusses these two analysis modes and the Series 20's architecture.

5.1 PULSE HEIGHT ANALYSIS

In the PHA operating mode, a train of pulses, such as those from a radiation detector, are applied to the input of the Series 20. These pulses have amplitudes (heights) which are proportional to the energies of the incident radiation that was absorbed by the detector. By counting the number of occurrences of pulses of each height and forming a histogram, the Series 20 records the radiation energy spectrum as seen by the detector.

A better term for Pulse Height Analysis would be Pulse Height Distribution Analysis, because the input pulses are sorted by voltage amplitude to yield a histogram representing frequency of occurrence versus pulse height. A pictorial representation of this process can be seen in figures 5.1 and 5.2.

Figure 5.1 depicts a series of voltage pulses as they might appear at the input to the Series 20. The vertical axis has been divided into ten equally spaced intervals, each representing one volt of pulse height. The number of pulses falling into each of the various intervals is tabulated at the right of the figure.

This same data is then shown in histogram form in figure 5.2, where the horizontal axis divisions correspond to the voltage divisions on the original signal. It is this type of pulse height distribution analysis that is performed by the Series 20 MCA during PHA mode data acquisition.

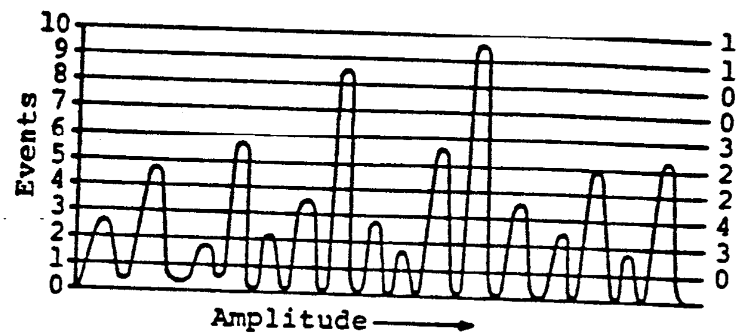


Figure 5.1
Input Voltage Pulses

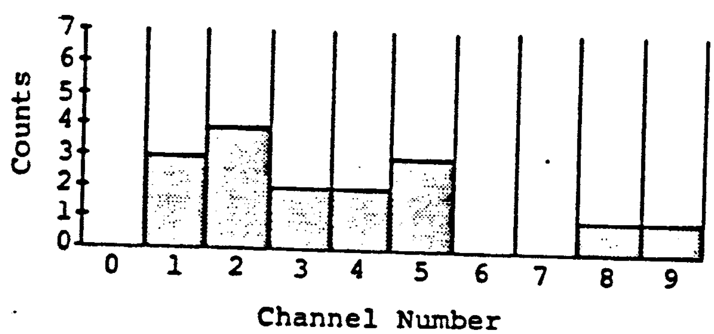


Figure 5.2
PHA Histogram

The primary application of PHA operation is in the quantification of the output signals from the class of radiation detectors whose output is a current or voltage pulse proportional in amplitude to the energy absorbed by the detector. Typical of such detectors are: Scintillation detectors such as NaI (Tl); Semiconductor detectors such as Ge(Li), HPGe, Si(Li); and Gas Proportional detectors.

A common characteristic of all these detectors is that each current or voltage pulse produced by the detector corresponds to the energy deposited by an individual photon or particle. Since the nuclear or atomic decay which generates the incident radiation is a randomly occurring process, the pulse train from the detector to the Series 20 is a time-random mixture of pulses of all possible amplitudes.

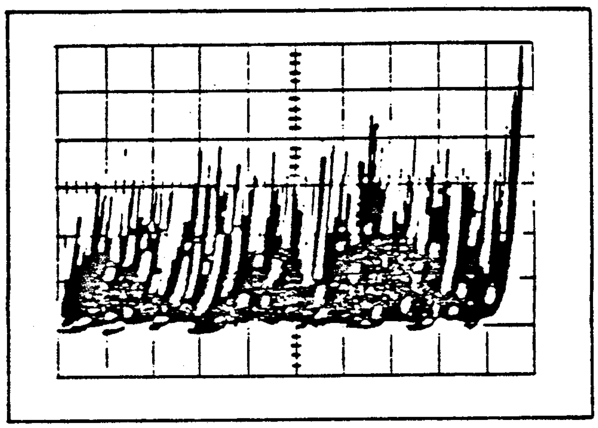


Figure 5.3
Voltage Train Output
from a Ge detector

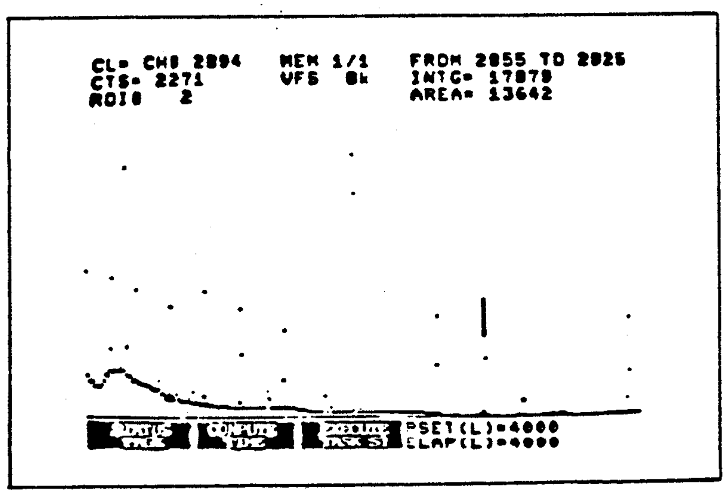


Figure 5.4
Resultant PHA
Histogram

The job of the Series 20, in PHA operation, is to sort this pulse train by amplitude and store the resultant spectrum. This can be seen graphically in figures 5.3 and 5.4, where both the detector output and PHA histogram for a mixed gamma source are shown.

The 4096 channel histogram shown in figure 5.4 is directly analogous to the ten channel histogram in figure 5.2 but is of far greater resolution. That is, the input pulses have been sorted into 4096 discrete amplitude levels rather than just ten levels. Each point in the figure 5.4 display represents the number of counts accumulated in one particular channel; it is still a pulse height distribution histogram.

From an analytical point of view, a PHA distribution histogram (spectrum) can provide both qualitative and quantitative results. Since channel number corresponds to input voltage, and input voltage corresponds to the energy of the radiation striking the detector, the energy of any peak in the spectrum can be easily determined; and from the energy (or energies) present one can determine the source.

The spectrum can also yield quantitative data. Since all measurements of radiation intensity are based upon the number of events per unit time, one need only divide the number of occurrences of a given energy by the total acquisition time to get a measure of the activity present. This is an over-simplification, since there are many other physics-related factors that must also be considered. The principle of "counts divided by time" is still valid.

5.2 TRUE TIME

Because of the counts divided by time principle, the Series 20 stores acquisition time along with the spectral data when operating in the PHA mode. Channels 0 and 1 of the Series 20's memory are reserved for the time storage function. Channel 0 stores Live Time and channel 1 stores True (real) Time.

5.3 LIVE TIME

The time value stored in channel 0 is generated by a special circuit called a "live time clock", and the value accumulated is called the "live time". The need for this special time circuit can be seen by examining in closer detail the PHA mode of operation in relation to the input pulse train.

From a time standpoint, the input pulse train is totally random in nature. Therefore, since it does take the analog-to-digital converter (ADC) a finite amount of time to convert a pulse amplitude into a channel number, some pulses will arrive at the ADC only to discover that it is busy processing the previous pulse. The ADC is effectively "dead" and this datum (pulse) is lost.

The True and Live Time clocks are derived from separate quartz-crystal-controlled oscillators. The oscillators are extremely stable, with an absolute accuracy within 0.1%.

5.4 DEAD TIME

Because of this "dead-time" phenomenon, a time correction circuit is required to compensate for the fact that the number of input pulses per unit time can vary considerably from the number of events stored per unit time.

This time correction circuit, called the "live time clock", extends the total elapsed counting time to compensate for the percentage of time that the ADC is "busy". This circuitry can be seen in operation via the Percent Dead Time bar-graph at the top of the Series 20's display.

For PHA operation, the primary goals are, therefore, the ability to measure the distribution of input pulse heights and to keep track of the system live counting time. The time function is automatically handled via the live time clock and requires no parametric input. However, the Series 20 does provide several methods for modifying the parameters of the pulse height distribution function.

5.5 ADC GAIN

One of the factors affecting the generation of a pulse height distribution histogram is the system resolution; that is, the number of discrete voltage levels --or channels-- into which the input pulses will be sorted. In ADC terminology, this is called the ADC Conversion Gain. For example, our initial histogram (in figure 5.2) used ten separate one-volt levels for sorting; it had an ADC Gain of 10.

For most PHA operations, the intent is to analyze the input voltage over its entire 0 to 5 volt range. To do this with maximum resolution, the ADC Gain is set equal to the Memory Size. For a 4096 channel (4K) memory, this corresponds to an ADC Gain of 4096.

Alternatively, an ADC Gain of 2048 channels would allow two separate spectra to be stored in either half of the 4096 channel memory.

5.6 DIGITAL OFFSET

If we were interested only in the first 2.5 volts of the zero to 5.0 volt input range, the experiment's setup would be quite straightforward, as shown in figure 5.5. Pulses below the 2.5 volt (channel 2048) level are converted and stored; those above are ignored.

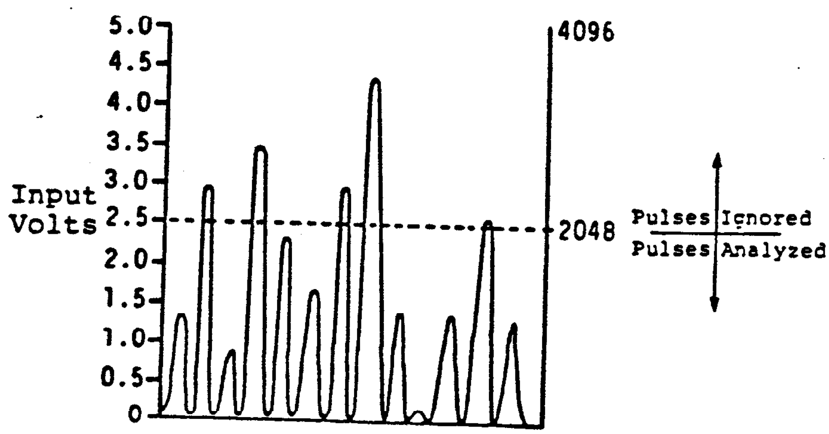


Figure 5.5
Effect of 4K Gain and 2K Memory

But what if the objective is to analyze those pulses in the 2.5 to 5.0 volt range: how can this be accomplished? It is in this situation where the value of ADC Offset can be seen.

Up to this point, it has been assumed that ADC channel numbers and memory channel numbers are the same. Actually they are independent: the ADC Offset control establishes their relationship.

When the ADC and memory channel numbers are the same, the ADC Offset is said to be zero. This relationship can be shifted linearly via the ADC Offset control.

For example, to analyze the upper 2.5 to 5.0 volts of the input using a 4096 channel ADC Gain and a 2048 channel memory, we need to "shift" the memory's zero channel to correspond to ADC channel 2048. This requires an ADC Offset of 2048 channels.

The Series 20 includes ADC Offset settings of 0 to 4000 channels to allow the selection of the optimum value for any given situation.

5.7 MULTICHANNEL SCALING

MCS analysis yields a histogram representing number of events (radiation intensity) versus time. Just as in PHA, the input signal is a train of pulses, each representing a single event. However, in MCS analysis, any input pulse within the SCA window will be converted. The data stored is simply the number of these individual pulses which were received in a given period of time.

As pulses are discriminated by the SCA at the Series 20's input, MCS mode operation counts them one-by-one into the current memory channel for a predetermined period of time. At the end of this time period, which is called the dwell time, the MCS time base advances to the next memory channel address. Pulses are now counted into this channel for the dwell time period. Each memory channel is thus sequentially selected as a function of time.

MCS analysis finds use in several applications involving the study of the distribution of events as a function of time. One such application is the study of nuclear decay; the resultant MCS histogram represents the exponential decay curve.

5.8 DWELL TIME

For all applications an appropriate dwell time must be selected prior to the analysis. Several factors can influence this choice.

1. Desired time for the entire scan.
2. Number of channels to be used for data storage.
3. Desired counting statistics (number of counts per channel).
4. Operating rate of an external device.

5.9 MCS HISTOGRAM

The MCS mode of operation can be seen in a simplified form in figures 5.6 and 5.7. The input pulse train in 5.6 would generate the histogram shown in 5.7. Note that an MCS analysis produces an integral histogram; each channel represents the summation of all counts within the given time period.

Figure 5.6
MCS Input
Pulse Train

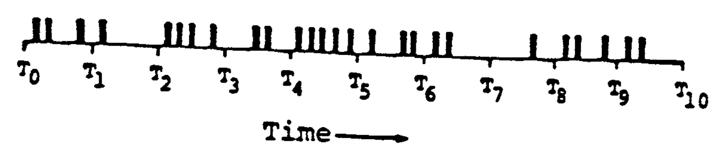
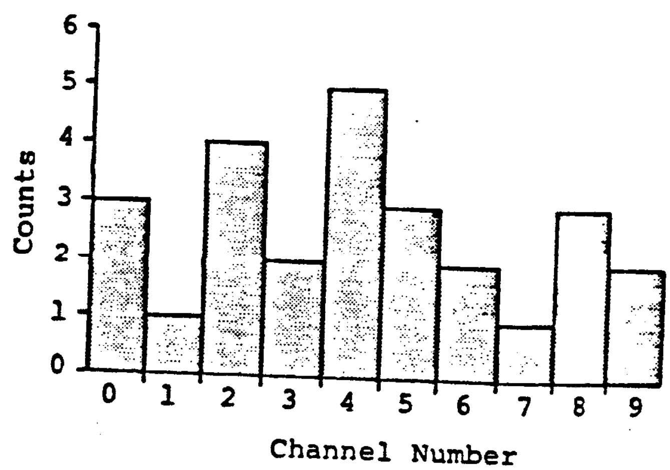


Figure 5.7
MCS Histogram



5.10 ARCHITECTURE

The Series 20 comprises a power supply, a keyboard, a cathode-ray tube (CRT) display, and plug-in printed circuit boards for the master processor, the display processor, and the amplifier and analog-to- digital converter (ADC).

Each of the two processors has an associated EPROM (Erasable Programmable Read Only Memory) for instruction storage and RAM (Random Access Memory) for data and temporary storage.

The display processor supports the operator interface by servicing keyboard requests and maintaining the display. The complete RAM memory is also on this board. One section of RAM consumes very little power and can be kept active for several weeks when the ac power is off. The "keep alive" power is supplied by a nickel-cadmium battery located on the power supply.

When ac power is removed, all parameters, tasks, the ROI list, and equations are put into this memory, from which they are retreived when ac power is restored.

The data memory is normally lost with an ac power down. However, the optional Model 2883 Data Saver will provide enough power to keep this memory alive for short periods of time.

The master processor has overall control of data acquisition, input/output (I/O), computation, sequencing, and the operator interface. It includes a clock and calendar, the PHA/MCS time base, and the RS-232C and FSK I/O ports. It also controls the amplifier, the ADC, and the display processor.

The amplifier and ADC are fully programmable and can operate in either the PHA or MCS mode with additive or subtractive data storage. A direct memory access (DMA) interface is provided between the ADC and the data memory.

5.11 THE MEMORY

The memory consists of the programmable ROM, which contains both microprocessors' instructions (firmware), and the RAM, which stores the operator's instructions and the acquired data.

The Series 20 has 4096 (4K) channels of data memory. Memory storage in RAM can take place in the full memory, either half of the memory or any quarter or eighth of the memory. Data storage may be either in the Pulse Height Analysis (PHA) mode or the Multichannel Scaling (MCS) mode. The data may be added to or subtracted from the memory in either mode. In the Model 2802, a full 4K background RAM memory stores data during readout, thus allowing the data memory to collect new data.

5.12 THE DISPLAY

The Series 20's display processor directs the data in the memory to the CRT display and organizes it in readily understood format. You are supplied with a clear picture of the spectral data in memory with appropriate alphanumeric information to aid you in data interpretation.

In addition to the raster-scan CRT display, the Series 20 offers a rear panel RCA-type jack for a remote monitor or video printer. This output is RS-170 compatible.

5.13 THE SIGNAL PROCESSOR

The signal processing section includes a spectroscopy amplifier and an ADC. The ADC's input is factory set to accept the output of the internal amplifier, but can be configured to accept the output of an external amplifier (refer to section 4.1). The ADC converts the input linear signals to digital form and routes them to the appropriate memory location for storage and subsequent display, analysis and readout.

APPENDIX A SPECIFICATIONS

A.1 PROCESSOR

DATA MEMORY	4096 Channels; 2^{24}-1 counts/channel; full memory is divisible into 1/8s, 1/4s, or 1/2s
STORAGE MODES	PHA add or subtract; MCS add or subtract
PRESETS	Choice of: Live Time; Counts in a Channel; Integral of ROI; Area of ROI; True Time; or USE Function (in Model 2802 only). For MCS: number of sweeps; dwell time of 128 µs to 4.194 s in multiples of 64 µs
DISPLAY	CRT (Cathode Ray Tube); 17.8 cm (7 in.) measured diagonally; raster-scan display; Direct Memory Access (DMA) interface
Data Display:	• Linear and Log vertical scales • Intensified ROIs • Digitally-controlled cursor • Vertical Resolution 1 part in 190 • Horizontal Resolution 1 part in 512 • Horizontal expansion of 64 to 512 channels
Character Display:	• 16 lines of alphanumeric characters • About 40 characters per line
ROIs	Maximum of 50; can be overlapped
PERCENT DEAD TIME	Moving Bar (in PHA mode only)
BATTERY BACKUP	When ac power is off, all parameters and the system clock are kept alive for at least two weeks. The optional Model 2883 Data Saver keeps the data memory alive for at least 8 hours - typically for 12 hours.

A.2 AMPLIFIER	Programmable unipolar spectroscopy amplifier with gated active baseline restorer
SIGNAL INPUT	Voltage sensitive; accepts positive or negative tail pulses from the associated preamplifier; rear panel BNC Amplitude: 0 to ±12 V, max Rise Time: < 0.5 μs Decay Time Constant: 40 μs to ∞ Input Impedance: ≈ 1.5 kilohms
OUTPUT	0 to +5 V, full scale; directly connected to the ADC's input. Rear panel test point and pole/zero potentiometer to adjust for the input signal's decay time constant.
GAIN	Programmable; 3.5X to 1230X corresponding to a full scale input of 2.8 V to 8.2 mV
INPUT POLARITY	Programmable; positive or negative
PULSE SHAPING	Programmable; FAST (NaI) or SLOW (Ge)

Characteristic	Fast	Slow
Time to Peak	4.4 μs	7.5 μs
Pulse Width	12.5 μs	25.0 μs

Width measured at 0.2% of full scale output

INTEGRAL NON-LINEARITY	Slow Shaping: ≤±0.05% of full scale output range Fast Shaping: ≤±0.10% of full scale output range
OVERLOAD RECOVERY	Recovers to within ±2% of full scale output from X200 overload in three non-overloaded pulse widths when properly pole-zeroed.
NOISE CONTRIBUTION	Slow Shaping: ≤20 μV true rms, referenced to the input at 1200 gain Fast Shaping: ≤35 μV true rms, referenced to the input at 1200 gain
PEAK SHIFT	≤0.05% of full scale, to 50 kHz (includes ADC)

DRIFT	GAIN:	≤±0.02% per °C
	ZERO:	≤±25 µV (0.0005%) per °C

SPECTRUM BROADENING

With SLOW shaping selected, 90% of full scale pulse height and incoming count rate of 2 kcps, the FWHM of the ^{60}Co 1.33 MeV gamma peak is typically less than 250 eV broader than a spectrum taken with an 8K ADC and a spectroscopy amplifier with comparable unipolar shaping.

For a count rate change from 2 kcps to 50 kcps, the FWHM will typically change less than 30% and the peak will typically shift less than 0.05%. The amplifier/ADC will process pulses at rates in excess of 100 kcps.

A.3 ADC

Pulse stretcher with programmable Wilkinson converter having a 100 MHz clock; 4K conversion gain and range (Model 2801 = 2K gain, maximum).

INPUT

Full scale calibrated for +5.0 V; rear panel BNC; internal jumpers allow input from external amplifier; minimum rise time = 0.5 µs; minimum width = 1 µs; Z_{in} = 10 kilohms, nominal.

GATE

TTL input to enable conversion in PHA mode or count in MCS mode. Open circuit or positive level enables; low level (0 to 0.5 V) disables. For proper operation, the Gate signal must be valid from the time of the input's peak amplitude until the signal drops more than 10% from the peak amplitude.

PEAK DETECT

Constant fraction circuit. Conversion is initiated when the ADC input falls to 90% of its peak value.

SCA

Programmable; sets window on ADC's input to allow conversion in PHA mode or counting in MCS mode

Range:	0 to 110% of ADC Full Scale input
Drift:	<±0.025% of range per °C
Resolution:	LLD - 1/1024 of SCA Range
	ULD - 1/256 of SCA Range
Non-Linearity:	LLD - <±0.05% of SCA Range
	ULD - <±0.25% of SCA Range

CONVERSION GAIN	Programmable; 512, 1024, 2048 or 4096* channels per full scale (5 V) input (*not on Model 2801)
CONVERSION RANGE	Programmable; set by memory group selection at start of collect; 512-4096 channels in binary steps
DIGITAL OFFSET	Programmable from 0 to 4000 in 4 channel increments
ADC ZERO	Programmable; range = ±5% of full scale input in steps of ±0.04% (1/256)
PERCENT DEAD TIME	Bar graph during PHA data acquisition
NON-LINEARITY	Integral: <±0.025% of full scale over top 99% of the input range Differential: <±1% over top 99% of the input range
DRIFT	Zero: <±0.0025% of full scale Gain: <±0.01% of full scale Long Term: <0.005% of full scale per 24 hours
CONVERSION TIME	PHA Mode: <12.2 µs at channel 1024; <2+0.01 (N + D) µs where N = Converted Address, D = Digital Offset MCS Mode: <2 µs (Count rate to = 200 kHz with amp bypassed by internal jumpers - J5, J6, and J7 on ADC Board)
HOLD TIME	The ADC output is held in a latch. Direct Memory Access (DMA) logic in the Series 20 uses this address as the memory pointer. Average time to complete a cycle (latency and cycle time) is less than 4 µs. Hold time is the time needed to complete the previous DMA cycle after the Conversion ends.
ADC DEAD TIME	Equal to the Linear Gate Time plus the Conversion Time plus the Hold Time.

A.4 HIGH VOLTAGE POWER SUPPLY

RANGE AND POLARITY	0 to 1000 V; positive
CONTROLS	Amplitude set via duo-dial 10-turn locking potentiometer; ON/OFF locking toggle switch
CALIBRATION	within 0.2%
NON-LINEARITY	<0.3% of full scale
OUTPUT RIPPLE	<10 mV p-p at no load
DRIFT	<0.02% per °C
REGULATION	Line: <0.1% for 10% change in line voltage Load: 0.3% at 0 to 300 µA
OVERLOAD PROTECTION	Short-circuit proof and self-restoring
CONNECTOR	Rear panel SHV connector

A.5 FEATURES

STANDARD FEATURES (2801 and 2802)	SPECTRUM DISPLAY	Energy vs. counts (PHA) Time vs. counts (MCS)
	INTEGRAL	Full or ROI
	NET AREA	Full or ROI - 3 end points averaged
	SPECTRUM STRIP	Any memory group from any similar sized memory group
	SPECTRUM TRANSFER	Any memory group to any similar sized memory group
	OVERLAP	Any memory group over any similar sized memory group
	ENERGY CALIBRATION	2 point; PHA Units: eV, keV, MeV; MCS Units: µs, ms, or s
	INPUT/OUTPUT	EIA RS-232C port (to 19.2 kbaud); FSK port to cassette recorder; Video Output (RS-170 compatible)
	BATTERY BACKUP	All parameters and the internal clock are protected for up to 2 weeks
	EXTERNAL CONTROL INTERFACE	Four signals allowing the Series 20 to control a sample changer mechanism
ADDITIONAL FEATURES (2802 only)	LEARN/EXECUTE	Automatic routine sequencing
	DEFINE/USE	Algebraic user programming
	4K BACKGROUND MEMORY	Foreground memory can be transferred to background memory for readout

OPTIONAL FEATURES	HIGH VOLTAGE POWER SUPPLY	Model 2861 HVPS is suitable for NaI or Ge detectors; 0 to ±5 kV.
	SERVICE KIT	Model 2881 Field Service Kit includes schematics, extender boards, service manual
	NIM ENCLOSURE	Model 2882 bolt-on unit for NIM power supply or amplifier
	DATA SAVER	Model 2883 retains data in a power outage for at least 8 hours; 12 hours is typical
	PC INTERFACE*	Model 2884 Personal Computer Interface, cables, and S370 Utilities
	UL COMPONENTS	Model 2885 includes additional components approved by Underwriter's Laboratory
	AP-PAK*	Model 2886 preprogrammed equations for general nuclear analysis needs
	MED-PAK*	Model 2886N preprogrammed equations for nuclear medicine needs

*Available only with the Model 2802.

A.6 CONNECTORS

AMP In - BNC
GATE In - BNC
HVPS - SHV
EXT HVPS - 3-pin Molex

PREAMP POWER	- 9-pin	±12 V, ±24 V; ±5%
NIM POWER	- 15-pin	±12 V, ±24 V; ±5%
CASSETTE	- 9-pin	FSK (Frequency Shift Keying) output
EIA	- 25-pin	RS-232C compatible
VIDEO OUT	- RCA jack	RS-170 compatible
LINE (ac)	- 3-pin	Fused; input voltage is selectable

A.7 ACCESSORIES

C1515 cable - FSK to Model 5421M Cassette Recorder

A.8 PHYSICAL

SIZE: 22.2 x 23.4 x 39.9 cm (8.725 x 9.2 x 15.69 in.)
WEIGHT: approximately 11.3 kg (25 lb.)
POWER:
50/60 Hz, 60 W
Rear panel selectable for
95 - 105 V
105 - 125 V
190 - 210 V
210 - 250 V

OPERATING TEMPERATURE - 0° to 35° C, ambient

RFI/EMI EMISSION - FCC 47 CFR Part 15 compliance (for Class A equipment).

APPENDIX B DIAGNOSTICS AND ERROR MESSAGES

The Series 20 may display an error message during normal operation or while performing diagnostics tests (section 3.10). All error messages are cleared by pressing CLEAR ENTRY when not in a dialog mode.

Some error messages seen during normal operation are self-explanatory, such as "ADC BUSY". Others are coded as "ERR n"; these are explained in section B.1. Section B.2 defines error messages which may be seen during diagnostics tests.

B.1 ERRORS MESSAGES DURING NORMAL OPERATION

ERR 1	Parameters not read in because Collect is active.
ERR 5	Start channel greater than Stop channel
ERR 6	The upper ROI limit exceeds the memory group maximum channel number. (Exit CHANGE ROI before pressing CLEAR ENTRY).
ERR 9	Parity error in data being read in.
ERR 10	Framing error in data being read in.
ERR 11	Parity and framing errors in data being read in.
ERR 12	Overrun error in data being read in.
ERR 13	Overrun and parity errors in data being read in.
ERR 14	Overrun and framing errors in data being read in.
ERR 15	Overrun, framing, and parity errors in data being read in.
ERR 16	Wrong file type being read in; for instance, Sequence file into Function file.
ERR 17	Bad data block in spectrum header being read in.
ERR 20	Buffer overflow; equation too long.
ERR 21	Illegal function call; Fn current can't be $\geq$ Fn called.
ERR 22	Use-stack overflow; equation is too long.
ERR 23	Use-stack underflow; equation is incomplete.
ERR 24	Use-stack unresolved; for instance, more opening than closing parentheses in the equation.
ERR 25	Undefined ROI in the equation.
ERR 26	Equation operator rejected; meaningless.
ERR 30	Overflow; learn sequence is too long.
ERR 50	Learn/Execute error. Task being executed has attempted to enter more than 50 ROIs via the ENTER ROI NEXT sequence. Task will continue execution, but will overwrite ROI# 50.

B.2 DIAGNOSTIC ERRORS

The Diagnostic routines test the PROMs, the RAM, the ADC, the SCA, and the EIA/FSK port.

B.2.1 PROM Test

The PROM test will show either "PROMS OK" or the socket location of the first PROM to fail the test. PROMs on the CPU board are indicated by "M"; those on the Display Processor board are indicated by "D".

B.2.2 RAM Test

The RAM test will show either "RAM OK" or a decimal failure address. Use table B.1 to convert the decimal address to the faulty RAM chip numbers.

Table B.1
Decimal Address vs. Chip Locations

Decimal Address Range	Hexadecimal Address	Low Nibble Location	High Nibble Location
32768-49151	8000-BFFF	A49	A47
49152-65535	C000-FFFF	A50	A48

B.2.3 ADC Test

For firmware version B1 and later, this test requires an input from an external precision pulse generator. The pulser's rate must be stable at any rate from 50 to greater than 2000 pulses per second. If the Amp/ADC board's amp jumpers are set to INT, the pulser's amplitude must be adjusted to store at about 60% of full scale with the following parameters.

Amp polarity = POSITIVE
shaping = SLOW
gain = 46

SCA LLD = 0%
ULD = 110%

ADC Offset = 0
Zero = -5%
Gain = 4096
(2048 for 2801)

With a Model 2801, storage should be between channels 1250 and 1300; with a Model 2802, adjust the amplitude to store between channels 2500 and 2600. The internal amplifier may be bypassed by moving the Amp/ADC board's amp jumpers to EXT and setting the pulser to about +3 V to test the ADC.

The ADC test checks the following ADC functions: ADC Gain, Offset, Range, Base, Zero; the SCA LLD and ULD; and the PHA-ADD, PHA-SUB, and MCS operating modes.

The test message, which will appear on the display, gives the Pass Number and the Status Code. The Pass Number is the number of ADC Test cycles that have been completed when either the STOP soft key is pressed or an error is found.

The Status Code listed in the following sections identifies the first error found. If occasional failures on random tests are found, it may be because of short-term drift in the pulser. In most of the tests, the ADC diagnostic program is looking for storage in a particular range of channels. If an error is found, a marker is entered by adding 256 to the channels at the upper and lower limit of the expected range.

If there is a problem, the ADC (and Amp) should be set to the parameters noted at the beginning of this subsection and as given by the error message. The normal collect function can then be enabled to troubleshoot the ADC.

1) STATUS: 128, 0 = ADC Passed Test.

2) STATUS: 1, N = GAIN Error,
where

N	Gain Failed
1	512
2	1024
3	2048
4	4096

3) STATUS: 2, N = OFFSET Error, (ADC Gain is set to 4096)
where

N	Offset Error	N	Offset Error
1	2048	6	64
2	1024	7	32
3	512	8	16
4	256	9	8
5	128	10	4

4) STATUS: 3, N = RANGE Error,
where

N	Range Failure	For ADC Gain of
1	256	512
2	512	512
3	512	1024
4	1024	1024
5	1024	2048
6	2048	2048
7	2048	4096

5) STATUS: 4, N = BASE Error, (ADC Gain is 512 and Offset is 128)
where

N	Base Failure	For Range of
1	2048	4096
2	1024	2048
3	512	1024
4	256	512
5	0	256

6) STATUS: 5, N = ZERO Error,
where

N	Zero Failure	Zero Value
1	1	-4.96%
2	2	-4.92%
3	4	-4.84%
4	8	-4.69%
5	16	-4.37%
6	32	-3.75%
7	64	-2.5%
8	128	0

7) STATUS: 6, 0 = SCA-ULD failed.
Use the SCA test to determine the value that failed.

8) STATUS: 7, 0 = SCA-LLD failed.
Use the SCA test to determine the value that failed.

9) STATUS: 8, 0 = PHA-ADD failure.
Failure may be in the ADC-to-memory interface on the memory board.

10) STATUS: 9, 0 = PHA-SUB failure.
Failure may be in the ADC-to-memory interface on the memory board.

11) STATUS: 10, N = MCS Failure,
where

N	MCS Failure
1	MCS last sweep control failed.
2	Data in wrong channel - first sweep

12) STATUS: 15, 15 = Data memory error.

Between each test, the memory is cleared one byte at a time. If the program detects a non-zero byte, it signals an error. This can indicate a memory error (use the RAM test to verify) or a failure by the program to disable the ADC's storage function.

B.2.4 SCA Test

To perform this test on a Model 2802 (2801), first

Set the ADC for:	Set the SCA for:
Gain = 4096 (2048)	LLD = 0%
Offset = 0	ULD = 110%
Zero = 0	

Connect the Series 20's INput to a signal source and adjust the Amp and source so that in 10 seconds at least one count is (two counts are) collected in each channel from less than channel 30 (16) to channel 4095 (2047), then enable the test. The internal amp may be bypassed and an external amp or sliding pulser used as an input.

SCA Test Messages

The status message, which will appear on the display, shows the Pass Count and Status Code. The first Status Number indicates which function failed and the second indicates the value of the function at failure. The test will automatically restart if an error is found or at the end of a complete cycle unless the STOP soft key is pressed.

1) STATUS: 144, 0 = SCA Test Passed.

2) STATUS: 7, N = LLD Test Failed,
where

N	LLD Bit Setting	% Setting
9	$2^5 = 32$	3.441
8	$2^5 + 2^0 = 33$	3.548
7	$2^5 + 2^1 = 34$	3.656
6	$2^5 + 2^2 = 36$	3.871
5	$2^5 + 2^3 = 40$	4.301
4	$2^5 + 2^4 = 48$	5.161
3	$2^6 = 64$	6.882
2	$2^7 = 128$	13.76
1	$2^8 = 256$	27.53
0	$2^9 = 512$	55.05
11	LLD = 0 - No data found ULD = 110%	0

3) STATUS: 6, N = ULD Test Failed, where

N	ULD Value	% Setting
8	127	54.78
7	128	55.22
6	128 + 1	55.65
5	128 + 2	56.08
4	128 + 4	56.94
3	128 + 8	58.67
2	128 + 16	62.12
1	128 + 32	69.02
0	128 + 64	82.82
9	ULD = 255 - No data found LLD = 0	110

4) STATUS: 15, 15

Data memory failure or failure to stop Collect. See ADC Test, section B.2.3.12.

B.2.5 EIA/FSK Test

To perform this test, the I/O Test Cable included in the Model 2881 Service Kit must be plugged into the CASSETTE and EIA connectors.

The CASSETTE plug connects the output data to an amplifier, through the contacts of the cassette relay (closed during the test), and into the input amplifier.

The EIA plug connects the data output amplifier to the data input amplifier and connects the DSR output to the FLAG input.

EIA/FSK Test Status Messages:

Status	Meaning
1	Test passed
5	No EIA data detected
7	Transmitter interrupt error
8	Receiver interrupt error
9	USART Status error
10	DTR error
11	RDY OUT or FLAG error
65	No FSK data detected
133	No FSK clock

APPENDIX C INPUT/OUTPUT FORMATS

This appendix describes the characteristics of the EIA port when in the LOCAL control mode. Refer to the Model 2884 PC Interface manual for details of its operation when in REMOTE control mode (Model 2802 only).

C.1 EIA/TERMINAL FORMAT

All data transmissions through the RS-232C port are in ASCII format except Computer which is in binary format. If EIA readout is selected, the Series 20 will transmit the non-printing control codes listed in Table C.1 prior to the corresponding data field.

Table C.1 EIA Control Codes

	Item	Octal	Hex	Code	Description
1.	Tagword	5	5	(ENQ)	8 digits, with leading spaces.
2.	Data ID	2	2	(STX)	24 ASCII characters[1].
3.	End field	3	3	(ETX)	Ends Data ID and ECAL coeff.
4.	Live Time	36	1E	(RS)	8 digits, with leading spaces.
5.	True Time	37	1F	(US)	8 digits, with leading spaces.
6.	ECAL units	11	9	(HT)	eV, keV, MeV, µs, ms, sec.
7.	ECAL "B" coeff.	7	7	(BELL)	Floating point field[1]
8.	ECAL "C" coeff.	10	8	(BS)	Floating point field[1]
9.	Channel Address	33	1B	(ESC)	5 digits, with leading spaces.
10.	Channel Data	17	F	(SI)	8 digits, with leading spaces.
11.	End of Data	4	4	(EOT)	End of transmission.

[1]These fields are terminated by (3) ETX.

If TERMINAL readout is selected, the only non-printing characters transmitted from the Series 20 are:

Carriage Return	$(0D)_H$	(followed by 4 NULLs and 1 LF.)
Line Feed	$(0A)_H$	
Space	$(20)_H$	
Null	$(00)_H$	

All other control codes are changed to NULLs.

C.2 TAPE FORMAT

The Tape format is the same as the Computer format (section C.3) but it is read out in FSK mode instead of binary mode.

The Tape Format is a record of the Status Page (section C.3.4) and all spectral data in the current memory region. It is meant to be used only with the Model 5421M Cassette Recorder. The Status Page information will be read back in with the data as described in section C.3.4.

Note: if Collect is active in another section of memory, ERR 1 will appear on the display's Status Line; the spectrum and time data will be read in without the Status Page. Use CLEAR ENTRY to clear the message, then disable COLLECT and repeat the readin to load the Status Page's parameters.

Using a Model 5421M Recorder, a Series 20 cassette tape can be read into the Series 10. Adding the Model 5421F Cassette Interface will allow the Series 20 tape to be read into the Series 35, 35 PLUS, 40, 80, 85, or 90 MCAs. Exception: the ECAL equation can't be read in by the Series 80 or 85 using the xx52/53E Cassette Interface.

C.3 COMPUTER FORMAT

The first line of a computer readout is in ASCII format, followed by binary data and parameters.

C.3.1 Overall Format

TAG NO. n DATA ID DATE TIME PAGE 1

Binary Data Block 1
Binary Data Block 2
Binary Data Block 3
•
•
Binary Data Block n

HEADER
$(01)_H$ $(04)_H$ $(53)_H$ XXX (←83 bytes)

Parameter Block (see section C.3.4, Status Page).

The HEADER is the Title and Summary information as listed in Table C.1 and illustrated in Appendix D.

C.3.2 Binary Data Block Format

$1C_H$
Region Channel Count Low Byte
Region Channel Count High Byte
Starting Channel Address Low Byte
Starting Channel Address High Byte

Data High Byte Data Low Byte Data Middle Byte	Data from the starting address in the memory region
•	•
•	•
Data High Byte Data Low Byte Data Middle Byte	Data from the last channel in the memory region

C.3.3 Read In

For READ IN from a computer, the Series 20 can accept a format of Binary Data Block(s) or Parameter Blocks for setup values, or both. If only Data Blocks are read in, the READ IN must be terminated by $(04)_H$.

C.3.4 Status Page

The Status Page (section 2.5) is read out with the spectrum data. It is also read in with the spectrum, except that the first line of the page and the EIA Baud rate are disregarded.

In addition to the Status Page, the Data ID, the ECAL coefficients, and the Start of Collect time are read out and in.

C.4 READOUT COMPATIBILITY

Table C.2 lists both Direct (RS-232C port) and Cassette Input/Output to and from other Canberra analyzers. Read In and Read Out are referenced to the Series 20.

Table C.2 Readout Compatibility

	DIRECT I/O		CASSETTE I/O	
Analyzer Model	Read Out[1]	Read In[2]	Read Out	Read In
S30, 4100, 8100, 8180	No	No	No	No
SERIES 10[3]	Yes	Yes	Yes	Yes
SERIES 35 and 35 PLUS	Yes	Yes	Yes	Yes
SERIES 40	Yes	Yes	Yes	Yes
SERIES 80	Yes	No[4]	Yes	Yes[5]
SERIES 85	Yes	No[4]	Yes	Yes[5]
SERIES 90	Yes	No[6]	Yes	No[6]

Notes:
1) Read out COMPUTER, ≤1200 baud, 8 bits/character, parity as enabled.
2) Read in EIA, binary, ≤1200 baud using RDY OUT from the Series 20 connected to FLAG IN to the Series 35/40; ≤600 Baud with no connection to RDY OUT. Requires putting the Series 20 in Read In or removing the cable if the transmitting Analyzer does not end Readout when all data is transmitted.
3) To transfer the Series 20's Status Page parameters to the Series 10, the Series 10 HV polarity plug must be set to +1 kV . It can be in any position when reading from the Series 10 to the Series 20.
4) Series 80/85 read out doesn't have EOT in the correct place for a terminal output.
5) Series 80/85 format doesn't include Live Time, True Time, ECAL, etc.
6) Series 20 can't read in Series 90 Data Format (4 bytes/channel).

C.5 Data Flow Control

The Series 20 provides for hardware handshaking as well as XON/XOFF software handshaking. The hardware lines used are Ready Out (J106, pin 5) and FLAG (J106, pin 11). Both are RS232 compatible and described in Appendix E.

In ASCII Read Out (EIA or TERMINAL) the analyzer will suspend transmission after an XOFF (Hex 13/ctrl S) until it receives an XON (Hex 11/ctrl Q).

During EIA Read In, the Series 20 will transmit an XOFF when its input buffer fills; the sending device must suspend transmission until the analyzer sends an XON.

```
TAG NO.        4           SERIES 20            17 JUL 84  11:53   PAGE  1
MEMORY= 1/1      LIVE TIME=     400 SECS     TRUE TIME=      400 SECS
COLLECT STARTED ON 17 JUL 84  AT  11:32:02
AMP: INPUT= POS  TC=SLOW  GAIN= 3.5000
SCA: LLD=     0%  ULD= 110.0%
ADC: GAIN=4096  OFFSET=   0  ZERO=    0%
     PHA ADD    PRESET=       1000s LT

CHANNEL#                          DATA
    0
16712080 16712080 16713514 16713279 16713359 16713277 16713279 16713289
    8
16713276 16713277 16713146 16713104 16713156 16713060 16713091     1363
   16      1391     1380     1395     1375     1406     1340     1251     1324
   24      1285     1248     1286     1190     1200     1234     1232     1172
   32      1256     1183     1178     1139     1187     1142     1130     1127
   40      1133     1049     1124     1112     1131     1090     1102     1079
   48      1090     1089     1095     1039     1056     1000     1109     1022
   56      1033     1026     1077      956     1010     1001      977      954
   64       975     1008      958      989      961     1002     1031      954
   72       983      944      968      982      989      951      989      953
   80       975      990      923      999      937      929      895      924
   88       980      956      942      926      913      950      925      880
   96       940      902      877      921      902      880      915      910
  104       942      965      877      877      938      899      886      900
  112       876      880      900      869      883      920      871      841
  120       881      888      854      831      852      903      918      881
  128       848      867      841      940      876      864      846      831
  136       863      889      832      864      843      804      830      834
  144       827      873      864      899      850      825      845      860
  152       865      884      821      851      824      896      878      814
  160       816      835      818      833      882      808      852      810
  168       852      852      863      845      839      862      848      825
  176       875      867      849      823      895      783      817      852
  184       802      847      843      820      786      844      842      825
  192       845      843      841      895      842      818      815      870
  200       862      822      820      814      834      834   [illegible]
  208       865      838      847      812      858  87[illegible]
  216       847      878      811      863      910
  224       855      879      809      815  77[illegible]
  232       892      799      843      824
  240       840      818      819  7[illegible]
            878      807      844
    [illegible]  83[illegible]
```

Figure D.1 Readout ALL

Shows format with some 8-digit data. After the last data channel is printed, line feeds are used to fill the page. There are 66 lines per page.

```
TAG NO.         4             SERIES 20              17 JUL 84   11:57   PAGE  1
MEMORY= 1/1       LIVE TIME=      400 SECS     TRUE TIME=       400 SECS
COLLECT STARTED ON 17 JUL 84  AT  11:32:02
AMP: INPUT= POS  TC=SLOW  GAIN= 3.5000
SCA: LLD=      0%  ULD= 110.0%
ADC: GAIN=4096  OFFSET=   0  ZERO=    0%
     PHA ADD    PRESET=        1000s LT

ROI#      FROM CH#  TO  CH#       INTEGRAL     AREA:BKG
  1          3226      3250          79808        73262
  2          3661      3693          67185        64623

CHANNEL#                               DATA
 3226       353      347      379      376      452      573      917     1545
 3234      3028     5122     8107    10889    12362    11881     9697     6552
 3242      3601     1672      752      322      198      191      162      183
 3250       147

 3661       129      138      126      140      143      146      132      180
 3669       159      192      206      231      302      493      823     1546
 3677      2813     4706     6969     8862    10004     9631     7847     5418
 3685      3207     1561      642      230       87       50       28       29
 3693        16
```

Figure D.2 Readout ROIS

After the last data channel is printed, line feeds are used to fill the page. There are 66 lines per page.

```
TAG NO.         4             SERIES 20              17 JUL 84   11:58   PAGE  1
MEMORY= 1/1       LIVE TIME=      400 SECS     TRUE TIME=       400 SECS
COLLECT STARTED ON 17 JUL 84  AT  11:32:02
AMP: INPUT= POS  TC=SLOW  GAIN= 3.5000
SCA: LLD=      0%  ULD= 110.0%
ADC: GAIN=4096  OFFSET=   0  ZERO=    0%
     PHA ADD    PRESET=        1000s LT

ROI#      FROM CH#  TO  CH#       INTEGRAL     AREA:BKG
  1          3226      3250          79808        73262
  2          3661      3693          67185        64623
```

Figure D.3 Readout BRIEF

After the last ROI summary is printed, several line feeds are used for spacing.

Number	Name	Pin	Signals (IN/OUT referred to Series 20)	
J101	HV OUT	SHV	High Voltage OUT: 0 to +1000 V; 300 μA, max.	
J102	EXT HVPS	1	Ground	
	3-pin Molex	2	+24 V; 300 mA, maximum	
J103	NIM POWER	1	+12 V; 160 mA	
	15-pin female	3	-12 V; 160 mA	
		5	+24 V; 80 mA	
		7	-24 V; 80 mA	
		9	Ground	
		11	Ground	
J104	PREAMP POWER			
	9-pin female	1	Ground	
		2	Ground	
		4	+12 V; 30 mA	
		6	-24 V; 50 mA	
		7	+24 V; 50 mA	
		9	-12 V; 30 mA	
J105	AC IN	Fused line power; voltage input is selectable.		
J106	EIA[1]	1	GND	Ground
	25-pin female	2	Data IN[2]	Received data, from device
		3	Data OUT[2]	Transmitted data, to device
		5	RDY OUT[3,4]	Ready to input, to device
		6	DSR[5]	Data Set Ready
		7	GND	Ground
		8	CD[5]	Received Line Signal Detect
		9	+12 V OUT	To power Model 9182
		10	-12 V OUT	Current-loop to EIA Adapter.
		11	FLAG IN[6]	Flag, from device
		20	DTR[5]	Data Terminal Ready
		22	Stop Collect In[7]	
		23	Ready In[7]	
		24	Collect Status Out[7]	
		25	Sample Changer Advance Out[7]	

[1]Unused EIA pins are reserved
[2]RS-232 compatible: Mark (logic 1) = -5V; Space = +5 V
[3]RS-232 compatible: Logic 1 = +5 V; Logic 0 = -5V
[4]When EIA port able to accept a character during input modes
[5]3 kilohm pull-up to 5 V; pullup voltage switched off (open) when the MCA is in Local and not doing I/O to the EIA port
[6]TTL or RS-232 LOW suspends transmission from S-20 after current character
[7]External Control signal; refer to appendix L

Number	Name	Pin	Signals (IN/OUT referred to Series 20)
J107	Reserved		
J108	GATE IN	BNC	Gate Signals IN. Open circuit or positive level enables; low level (0 to 0.5 V) disables.
J109	VIDEO OUT	RCA	RS-170 compatible; non-interlaced; composite; frame = field = line frequency; Hsync = 64 µs; Vsync =16.7 ms at 60 Hz, 20 ms at 50 Hz; level = 0.5 to = 2.5 V; positive polarity = light; negative polarity = sync
J110	CASSETTE	1	Motor control contact; rated for 200 mA maximum
	9-pin male	2	FSK ground
		3	Motor control contact; rated for 200 mA maximum
		4	FSK IN
		5	FSK OUT
J111	Reserved		
J112	SIGNAL IN	BNC	Linear Signals IN. Amp or ADC input; factory-set for amp input. Refer to appendix A for amp and ADC input parameters.

APPENDIX F POLE/ZERO ADJUSTMENT

The pole/zero (P/Z) control is used to compensate for the fall-time constant of the preamplifier's output signal and the amplifier's shaping-time constant. The P/Z control is factory-set for a 50 µs tail-pulse input with slow amplifier shaping.

For best input signal resolution, the rear panel P/Z control should be properly adjusted for the amplifier shaping and the preamplifier used. It should be readjusted whenever either of these is changed.

To correctly trim the pole/zero:

1. Set the Series 20's amplifier for maximum gain and desired shaping (fast or slow). See section 3.2.
2. Attach a x1 oscilloscope probe to the ADC IN test jack on the Series 20's rear panel.
3. Ground the probe on any bare metal on the rear panel.
4. Set the scope for 100 mv/cm, vertical scale and for 20 or 50 µs/cm, horizontal scale.

Some scopes may overload from the 5 V signal when vertical sensitivity is at 100 mV/cm. This can cause the P/Z setting to be misadjusted. Canberra recommends the Model LB1502 Schottky Clamp Box be used to eliminate scope overload.

While looking at the ADC IN signal on the scope, turn the P/Z control (in the lower right corner of the rear panel) so that the trailing edge of the amplifier signal returns to the baseline with no overshoot or undershoot.

Figure F.1 shows a pole/zero. The three traces show correct p/z, undershoot, and overshoot.

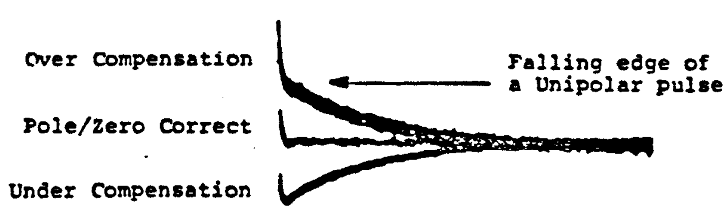


Figure F.1 Pole/Zero Adjustment

The ADC ZERO should be recalibrated each time the ADC GAIN is changed, though it is not critical.

A quick adjustment of the ADC ZERO can be done using an Energy Calibrated spectrum:

1. Clear the memory, collect a spectrum and Energy Calibrate it (be sure to clear any old ECAL equation before starting). Refer to section 3.12.

2. Make a note of the energy calibration equation.

3. Divide the equation's offset (last) term, by the energy per channel (the first term).

4. The result is the number of channels that the spectrum must be moved, using the ZERO parameter, to place zero energy in channel zero.

5. Divide the number found in step 4 by the ADC GAIN being used (512, 1024, 2048, or 4096) and multipy the result by 100. The resulting percent is the ADC ZERO to be entered, but must be entered as a number of the opposite sign. For instance, if the percent is 0.56, enter -0.56.

6. Clear the memory and add the percent found in step 5 to the current ADC ZERO parameter (section 3.1). Be sure to add the percent as a number of the opposite sign.

7. Repeat steps 1 and 2. When no further correction is necessary, the offset (last) term will now be at or very close to zero.

APPENDIX H CALCULATION ALGORITHMS

H.1 Integral Calculation

The integral, the sum of all data in the current Region of Interest (ROI), is found by:

$$I = I_p + B_1 + B_2$$

where

$$I_p = \sum_{a=b}^{a=c} X_a \qquad \text{(Peak Integral)}$$

$$B_1 = \sum_{a=d}^{a=e} X_a \qquad \text{(Left background)}$$

$$B_2 = \sum_{a=f}^{a=g} X_a \qquad \text{(Right background)}$$

X_a = contents of channel a.
b = Start + K
c = Stop - K
d = Start
e = Start + K-1
f = Stop - K+1
g = Stop
Start = ROI start channel (left limit)
Stop = ROI stop channel (right limit)
K = 3, the number of end points considered

H.2 Area Calculation

The peak area is found by:

$$A = I_p - \text{Background}$$

$$A = I_p - \frac{N \cdot (B_1 + B_2)}{(2 \cdot K)}$$

where
N = Stop - Start - 2k +1
K, B_1, B_2, Stop, and Start are defined in section H.1.

H.3 Strip Calculation

$$Y_a' = Y_a - F \cdot X_a$$

where
- F = the strip factor,
- X_a = the contents of channel "a" in the reference spectrum,
- Y_a = the contents of channel "a" in the original spectrum,
- Y_a' = the contents of channel "a" in the stripped spectrum.

The peak shown in figure H.1 illustrates the calculation of the functions defined in appendix H.

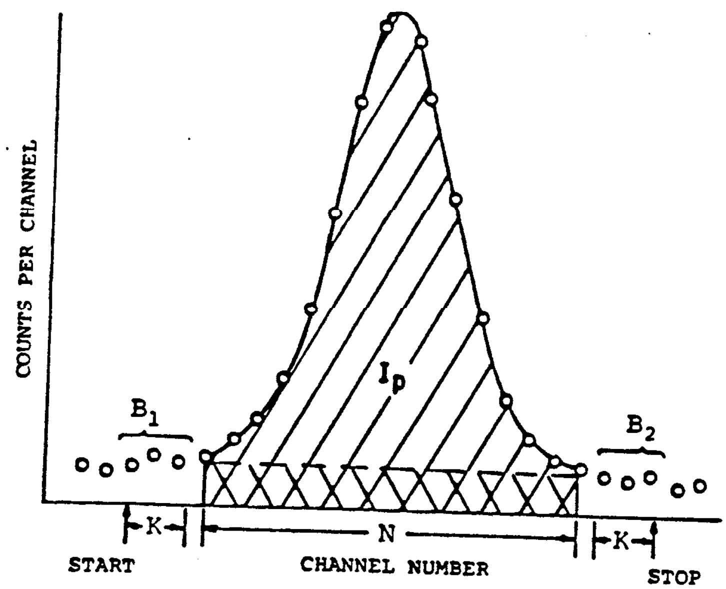


Figure H.1 Typical Spectrum Peak

APPENDIX I DEFINE/USE EQUATIONS

Appendix I.1 defines the set of general application equations which reside in the Series 20's memory unless replaced by user-defined equations. Appendix I.2 describes several other useful equations that can be entered, and appendix I.3 lists a set of Enrichment Measurement equations.

I.1 PREDEFINED EQUATIONS

a) Integral Ratio F1 = I/I1 where I = the Integral of the current ROI, I1 = the Integral of ROI# 1.

b) Area Ratio F2 = A/A1 where A = the Area of the current ROI, A1 = the Area of ROI# 1.

c) Cursor Ratio F3 = @C/I1 where @C = the contents of the current cursor channel, I1 = the Integral of ROI# 1.

If ROI# 1 is a single-channel ROI, then this is a Counts Ratio.

d) Percent Error F4 = SQR(A+(I-A)*(H-L-5)/6)/A*F5

where:
- A = Area of the current ROI,
- I = Integral of the current ROI,
- H = High channel number of the current ROI,
- L = Low channel number of the current ROI,
- F5 = 165.

I.2 OTHER USEFUL EQUATIONS

a) Counts per second:

CPS = Counts ÷ Live time

```
Fn = @#n/LT     n = channel #
   = In/LT      n = ROI #
   = An/LT      n = ROI #
   = @Ln/LT     n = ROI #
   = @Hn/LT     n = ROI #
```

b) Percent Error of an Integral:

$$\% \text{ Error} = 1.65 \times \frac{\sqrt{\text{Integral}}}{\text{Integral}} \times 100$$

Fn = 165/SQR(In)

c) Activity:

Bq = (Area ÷ Live Time) ÷ (Efficiency x Gammas per disintegration)

Fn = An/(LT/n1/n2)
where n1 = Efficiency
n2 = Gammas per disintegration

d) Conversion of Bq to µCi of Activity:

$\mu Ci = Bq \div (3.7 \times 10^4)$
Fm = Fn/3.7E04
where Fn is equation C, Activity.

e) Original Activity:

$\text{Original Activity} = \text{Activity now} \times e^{(0.693 t/T1/2)}$
Fm = Fn * EXP(0.693 * n1/n2)
where Fn = Equation C, Activity
n1 = decay time (t)
n2 = half-life (T1/2)

f) Percent Dead Time:

$\%DT = (T_{true} - T_{live}) \div T_{true} \times 100$
Fn = (TT-LT)/TT * 100

g) Radiochemical Component in Paper Chromatography:

$\text{Component} = C_p \div C_s \times 100$
where C_p = counts in the peak of interest
C_s = counts in the entire spectrum

Fn = In/Im * 100
where n = ROI# of the peak of interest
m = ROI# of full-spectrum ROI

I.3 ENRICHMENT MEASUREMENT EQUATIONS

The Enrichment calculation, often used in a Safeguards application, is a measure of the ^{235}U in a sample. It compares the count rate in the 186 keV peak to two known standards. The equations are derived from the following relationships:

$E = AC_1 + BC_2$

where
- E = Percent enrichment of the sample
- C_1 = Count Rate in the 186 keV peak window
- C_2 = Count Rate in the background window
- A and B are constants obtained from the spectra of the two standards

$$A = \frac{E_1C_{22} - E_2C_{21}}{C_{11}C_{22} - C_{12}C_{21}}$$

$$B = \frac{E_2C_{11} - E_1C_{12}}{C_{11}C_{22} - C_{12}C_{21}}$$

where:
- E_1 = Percent Enrichment of High Standard
- E_2 = Percent Enrichment of Low Standard
- C_{11} = Count Rate in 186 keV window of High Standard
- C_{12} = Count Rate in 186 keV window of Low Standard
- C_{21} = Count Rate in background window of High Standard
- C_{22} = Count Rate in background window of Low Standard

$$\text{Count Rate} = \frac{\text{Integral of window}}{\text{Live Time of Collection}}$$

All five of the USE equations are required to determine the Enrichment. They can be loaded into the parameters memory in place of the default equations.

The equations are:

```
F1 = (F2*I1-F3*I2)/LT
F2 = (F4+F3*I4)/I3
F3 = (F5-F4*I5/I3)/(I4*I5/I3-I6)
F4 = @2048*L
F5 = @3072*H
```

The elements L (low) and H (high) in F4 and F5 must be replaced by the Percent Enrichment E_2 and E_1 (Low and High Standards). To do this press:

MENU ANALYZE DEFINE F4 CLEAR ONE CONTINUE #
Enter the percent enrichment of the low standard.
Press END

MENU ANALYZE DEFINE F5 CLEAR ONE CONTINUE #
Enter the percent enrichment of the high standard.
Press END

Collect a spectrum of the high enrichment standard in the fourth memory quarter (4/4) and a spectrum of the low enrichment standard in the third memory quarter (3/4). Enrichment measurement will be made by collecting a spectrum in quarter 1.

Setup the following regions of interest:

ROI #1	quarter 1	186 keV peak
ROI #2	quarter 1	background region
ROI #3	quarter 3	186 keV peak
ROI #4	quarter 3	background region
ROI #5	quarter 4	186 keV peak
ROI #6	quarter 4	background region

It is important that the peak and background ROIs in all three quarters occupy the same relative channel positions. This can be easily accomplished by setting the display memory to quarters to enter the ROI start and stop channels.

To perform the enrichment calculation select memory quarter 1 and press:

MENU COMPUTE FUNC F1 ENTER

The answer will appear as "F1= n.nnnnnnE nn".

Note that after collecting the two spectra from the standards in quarters 3 and 4, the values of F2 and F3 will be constants that can be evaluated and then entered to replace F2 and F3 in F1 or as values for the F2 and F3 equations. In this way equations can be made available for other calculations.

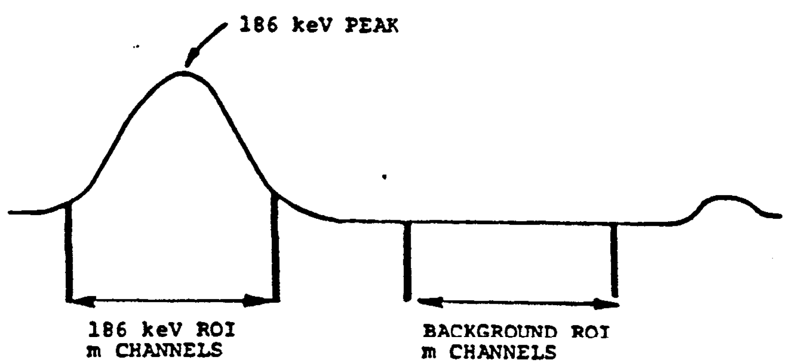


Figure I.1 Peak and Background ROIs

APPENDIX J MODEL 2886 AP-PAK

The Model 2802 Series 20 can include the optional Model 2886 AP-PAK. It offers predefined USE equations in addition to the five User definable equations (appendix I). These are stored in permanent (PROM) memory and enabled through the Menu dialog. With the option installed, the compute selection becomes:

Approach: [MENU] (COMPUTE)

Choose: (FUNC) (OFF) (TIME) (AP-PAK)

The Model 2886 AP-PAK soft key choices are:

DCACT	ACTIV	%ERR	CPS	ETC.
DOSE	EFFIC	%DT	CPM	ETC.
I/I1	A/A1	C/C1		ETC.

The Model 2886 AP-PAK's equations were chosen for their usefulness in a wide variety of applied nuclear experiments. The equations aid in generating reports from Series 20 data.

Once enabled , the selected equation can be evaluated by pressing the COMPUTE AP-PAK soft-key on the normal display. The selected equation will be included in any subsequent READ OUT and identified on the STATUS PAGE. To disable the equation, the normal FUNCTION OFF procedure is followed (MENU, COMPUTE, OFF; see section 3.7, Compute).

Several of the AP-PAK equations require parameters and ROI entry. The parameters are constants; for example, EFFICIENCY requires Half Life, Decay Time, and Gammas per Second. The parameters are entered using one of the user defined equations F1 through F5. Clear the appropriate Fn, then set it to the correct value using the number-entry method.

When an ROI is required, the equation evaluates either the Current ROI if A, I, H, L is included, ROI #1 if A1 or I1 is included, or ROI #2 if A2 is included. The equations listed in the following sections use the terminology given in the description of the DEFINE Key (section 3.9).

Table J.1 lists each AP-PAK equation with its keyword and the reference section (of this appendix) which describes the equation. To use these equations, enter the appropriate ROIs in the spectrum and the specified Functions (F1-F5).

Note - the solution of the EFFIC equation is used as F5 in three other equations: ACTIV, DCACT, and DOSE. To solve these equations, first solve EFFIC then enter the numeric value of its answer in F5.

Table J.1 The Equations

Key Word	Reference Section	Equation
A/A1	J.6	A/A1 where A = Area of the current ROI A1 = Area of the reference ROI
ACTIV	J.1	(A/LT)/(3.7E4*F4*F5) where A = Area of the current ROI LT = Live Time F4 = gammas per disintegration at peak energy F5 = detector efficiency at peak energy
C/C1	J.6	@C/I1 where @C = the cursor's current channel number I1 is a one-channel ROI (reference channel)
CPS	J.2	A/LT where A = Area of the current ROI LT = Live Time
CPM	J.2	A/LT*60 where A = Area of the current ROI LT = Live Time

Key Word	Reference Section	Equation
DCACT	J.3	(A/LT)/(3.7E4*F4*F5)/EXP(-.693*F3/F2) where A = Area of the current ROI LT = Live Time F2 = half life F3 = decay time F4 = gammas per disintegration at peak energy F5 = detector efficiency at peak energy
DOSE	J.4	(.53*F1*((A/LT)/(3.7E4*F4*F5))*1E-6)/(F2*F2) where A = Area of the current ROI LT = Live Time F1 = total keV per disintegration F2 = detector to source distance in meters F4 = gammas per disintegration at peak energy F5 = detector efficiency at peak energy
EFFIC	J.5	(A/LT)/(F1*EXP(-.693*F3/F2)) where A = Area of the current ROI LT = Live Time F1 = gammas per second of the reference source at the peak energy F2 = half life of the reference source F3 = decay time of the reference source
I/I1	J.6	I/I1 where I = Integral of the current ROI I1 = Integral of the entire spectrum
%DT	J.7	100-100*LT/TT where LT = Live Time TT = True Time
%ERR	J.8	SQR(A+(I-A)*(H-L-5)/6)/A*165 where A = Area of the current ROI I = Integral of the current ROI H = Highest channel number in the current ROI L = Lowest channel number in the current ROI 165 = a sigma of 1.65, x 100 to yield percent.

J.1 ACTIV (Activity)

This equation calculates the activity of the current ROI in microcuries. The efficiency factor plotted previously from the standard source (see EFFIC) and the gammas per disintegration (yield) are constants that must be entered for each ROI and isotope peak being reported. If the result is to be reported in Becquerel units, then divide the gammas per disintegration by 3.7×10^4 and store in function F4.

J.2 CPM - CPS (Counts)

These calculate the area count rate in particular peaks specified by the ROI. If a total count rate of the spectrum is wanted, then it is best to define a function (Fn) equal to:

I3/LT *60 (per min) OR
I3/LT (per sec), where
I3 refers to ROI#3, an ROI of the full spectrum.

J.3 DCACT (Decay Corrected Activity)

This function is similar to ACTIV but corrects the activity equation for radionuclide decay. A positive number for the decay time gives the activity at some previous time; a negative number would give the activity at the specified time in the future.

J.4 DOSE (Exposure Rate)

This function estimates the exposure rate in mR/hour in air from a gamma point source. The source activity is calculated for a single reference peak, defined by ((A/LT)/(3.7E4*F4*F5)). The total exposure rate is the summation of all energies in the source:

$\Sigma(\text{energy}_i(\text{keV}/\gamma)*\text{intensity}_i(\gamma/\text{disintegration}))$

J.5 EFFIC (Efficiency)

If spectral quantitative analysis is desired, the Detector's Efficiency must first be determined over the range of interest. The general method is to collect a spectrum from a known source and determine the ratio of the number of events counted to the number of actual events. This is done for several peaks in the spectrum to allow plotting the efficiency curve. As an example, we can discuss some of the considerations with gamma spectra using Germanium (Ge) detectors.

A. Standard Source
The source should have a long half-life and several high activity peaks. A good choice, covering the range 80 to 1800 keV, is the NBS Mixed Radionuclide Standard number 4242C. It contains eleven well-defined peaks.

B. Geometry
The detector-source geometry must be exactly the same for the standard and the samples to be analyzed.

C. Counting Statistics
The standard spectrum must be collected for long enough time to minimize errors. The Percent Error function (%ERR) should be used to determine the counting error.

D. Count Rate
At high count rates, pulse pile-up can cause loss of an appreciable number of events. Two solutions to this problem are: calibrate with a source having approximately the same count rate as the sample; or use an amplifier providing dead time correction and pile-up rejection.

After collecting a spectrum from the standard:

1. Energy calibrate the Series 20 using the ECAL function and the standard's list of peak energies.

2. Enter an ROI around each peak. The ROI limits must be set to give at least 3 channels of background on either side of the peak. (See figure H.1.)

3. For each peak use the Series 20's EFFIC function to calculate the efficiency factor at that energy. Note that if the activity of the standard is given as microcuries (μCi) instead of gammas/second (γ/s) then: $\gamma/s = 3.7 \times 10^4 \times \text{Yield} \times \mu Ci$ (The yield can be found in most isotope tables.)

   The standard's half life and decay time (age) must be in the same time units (for instance, days or years)

4. Record and plot the efficiency factor calculated for each energy.

When using this data, it is not necessary to have the same amplifier gain as long as the spectrum is Energy Calibrated. It is recommended, however, that the Efficiency Calibration be routinely verified at a few points to guard against changes in the detector or electronics. The efficiency factor is used when an activity-related calculation is performed.

J.6 A/A1, C/C1, I/I1 (Ratios)	These are useful relations when comparing one or more unknown samples with a reference spectrum. Collect the reference in one memory segment and enter ROI#1 over the peak (Area), channel (Cursor), or range (Integral). Collect the sample spectrum in another memory segment with an equivalent ROI, then enable the appropriate ratio function.
J.7 %DT (Percent Dead Time)	This equation displays the percentage of the True (real) Time that the ADC is converting an input and is therefore "dead".
J.8 %ERR (Percent Error)	This function is useful in determining the counting statistics of the peak. The ROI used to define the peak must extend at least three channels on either side of the peak to calculate the background (see appendix H). The percent error value means that if repeated measurements of the spectrum are made, you can be statistically 90% confident (σ = 1.65) that the Area value will change by no more than plus or minus the calculated percent.

APPENDIX K MODEL 2883 DATA SAVER OPTION

The optional Model 2883 Data Saver is an internal lead-acid battery which will keep the data memory alive for at least 8 hours (typically for 12 hours) when ac power is not being supplied to the Series 20.

K.1 NORMAL MODE

The Normal Mode protects the data memory against unexpected power outages.

In this mode, the front panel INTENSITY switch is on and the rear panel STANDBY switch is in the DISABLE position. If line power is lost, the Data Saver battery will supply power to the data memory.

NOTE

If the front panel INTENSITY control is turned off in this mode, all data will be lost.

K.2 STANDBY MODE

If the rear panel STANDBY switch is moved to its ENABLE position while ac power is on, the front panel INTENSITY control can be turned off for short periods of time without losing data.

K.3 CHARGING THE DATA SAVER

The 2883 Data Saver battery is under continuous charge while ac power is applied to the Series 20. It takes about two days to fully charge the battery from a discharged condition. When the battery is fully charged, it can be expected to save data for 8 to 12 hours at 25°C ambient temperature.

K.4 INSTALLING THE DATA SAVER

The Data Saver option is normally installed at the factory. For field installation, refer to the Model 2883 Data Saver Installation Guide.

APPENDIX L EXTERNAL CONTROL SIGNALS

The External Control Signal Interface is a standard feature on the Series 20 (V B1 and later). These signals allow the Series 20 to control a sample changer mechanism, such as Canberra's Model 2405 Alpha/Beta Sample Changer or Searle's Model 1185 Sample Changer. The TTL-compatible signals are on pins 22 through 25 of the Series 20's EIA connector (J106).

L.1 SIGNAL SPECS

All four control signals are specified as:

Positive Input: 4.7 kilohm pullup to +5 V; >3.5 V = logic high; <1 V at 1 mA = logic low.

Positive Output: >4 V at 4 mA = logic high; <0.5 V at 5 mA = logic low

L.2 SIGNAL DESCRIPTIONS

Signal; Direction, relative to the Series 20; (pin no.)	Signal Description
Stop Collect Signal IN (pin 22)	A logic low on this pin causes Collect to end. The response to this input has a variable delay; the signal should be kept low until the Collect Status changes.
Ready Signal IN (pin 23)	A logic low on this pin delays the start of the next Collect until this signal is positive. This allows the MCA to wait until the Sample Changer is in a counting position. Collect mode must be initiated: by pressing the Collect key, from a Task (Sequence), or by a 2884 PC Interface command.
Collect Status Signal OUT (pin 24)	A logic low on this pin indicates that the Series 20 is in an active Collect Mode.
Sample Changer Advance Signal OUT (pin 25)	A logic low pulse on this pin indicates that the Series 20 has finished Collect. The minimum pulse width is 15 ms.

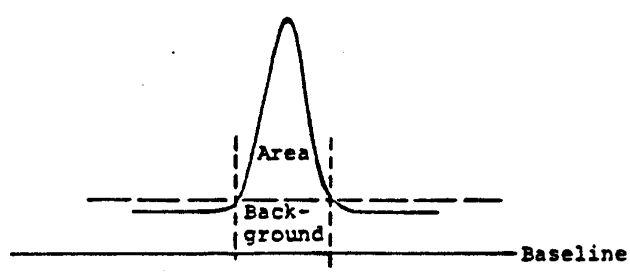
A

ADC -- Analog to Digital Converter. An electronic instrument which generates a digital word representing the magnitude of an analog signal.

ADDITIVE DATA ACQUISITION -- Incoming data is added to the data in memory.

ALGORITHM -- A set of well-defined rules for solving a problem.

AREA -- The number of counts in a given region that are above a determined background level. Equal to the region's integral minus the background.



Area = Integral-Background

ASCII -- American Standard Code for Information Interchange. A standard method of encoding alphabetical and numerical characters for digital transmission.

B

BNC -- A type of coaxial cable connector.

C

CENTROID -- The geometric "center of gravity" of a peak.

CHANNEL -- An MCA memory location used to store spectral data.

CLIPPED DISPLAY -- Data exceeding the VERTICAL FULL SCALE is truncated on the display but is complete in MEMORY. Compare WRAPPED DISPLAY.

COLLECT -- An MCA function that causes storage of data in MEMORY.

CONVERSION GAIN, ADC -- The number of discrete voltage levels that the ADC's full scale input is divided into. Commonly a binary multiple of 256 CHANNELs.

CRT -- Cathode Ray Tube. A visual display device similar to a television receiver picture tube.

CURSOR -- A vertical marker in the MCA display. Can be moved to a CHANNEL or REGION OF INTEREST; the display shows cursor location and channel count as numeric data.

D

DEAD TIME -- The time that the ADC is busy processing a signal and is not able to accept another pulse. Often expressed as a percentage.

DEFAULT-- The value of a PARAMETER used by a program in the absence of a user-supplied parameter.

DWELL TIME -- The sampling interval per CHANNEL in the MULTICHANNEL SCALING mode of data acquisition.

E

EIA RS-232C -- A (United States) Electronic Industries Association standard for transmitting digital information.

ENERGY CALIBRATION -- An MCA function which calibrates the displayed spectrum for a specific unit of energy or time per channel. Allows unknown peaks to be identified by their location in the calibrated SPECTRUM.

EXPAND -- An MCA function which expands a specified data region to the full width of the display screen for close examination.

F

FIRMWARE -- An unalterable program for the microprocessor stored in Read-Only Memory.

FSK - Frequency Shift Keying. A method of converting a pulse train of high and low logic levels (marks and spaces) to a train of frequencies. In the Canberra standard, a one (mark) is 1440 Hz and a zero (space) is 2880 Hz.

FWHM -- Full Width at Half Maximum. The full width of an energy distribution measured at half of its maximum amplitude. Defines the RESOLUTION of a SPECTRUM.

G

GATING -- The use of a LOGIC PULSE to trigger the acceptance or rejection of a input signal pulse by the ADC.

H

HARDWARE -- The physical electronics equipment. The Series 20's hardware is controlled by a FIRMWARE program.

HISTOGRAM -- A representation of an energy PEAK by means of vertical bars, the heights of which indicate the frequency of the energy events.

I

INPUT/OUTPUT -- The process of loading data into or copying data from an MCA using a PERIPHERAL DEVICE, such as a computer, a printer, or a cassette tape.

INDEX -- An MCA function that jumps the cursor from one REGION OF INTEREST to another.

INTEGRAL (MCA) -- The sum of the absolute number of counts in all CHANNELs in a given region. See AREA illustration.

INTENSIFY -- To make a region of the display brighter, visually setting a REGION OF INTEREST off from data regions of lesser importance.

I/O -- See INPUT/OUTPUT.

L

LIVE TIME -- The time that the ADC is not busy processing a signal.

LLD -- Lower Level Discriminator -- a comparator that outputs a LOGIC pulse when the ADC's input exceeds the comparator's preset reference voltage level.

LOGIC PULSE -- Generally refers to a TTL-compatible logic pulse: 2.5 to 5.0 volts is a high level; less than 0.8 volts is a low level. Width is defined by use.

M

MCA -- A Multichannel Analyzer.

MCS -- See Multichannel Scaling.

MEMORY -- An electronic device which acts as a data storage medium.

MULTICHANNEL SCALING -- Distribution of events versus time.

N

NIM -- Nuclear Instrumentation Module, such as an amplifier.

NIM BIN -- A frame providing mechanical support and power for a NIM unit.

NORMALIZE -- An MCA function which adjusts spectral data by addition of and/or multiplication by operator-specified factors. Used to adjust the data so that it falls within a prescribed range.

O

OFFSET, ADC -- A digitally performed shift in the ADC's zero CHANNEL. Shifts the entire SPECTRUM by the selected number of channels.

OVERLAP -- An MCA function where a section of MEMORY can be displayed with a reference section.

P

PARAMETER -- A variable that is given a constant value for a specified application.

PARITY -- A self-checking binary code in which the total number of ones (or zeros) in the encoded character is always even or always odd.

PARITY BIT -- A binary digit (bit) appended to a group of bits to make the sum of all the bits always odd (odd parity) or always even (even parity). Verifies data transmission.

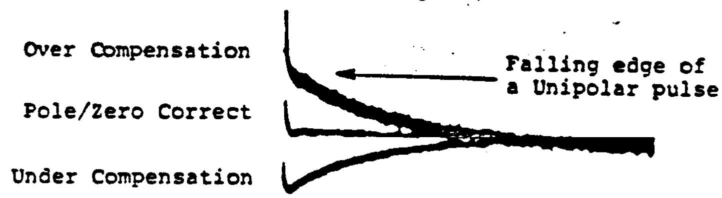
PEAK -- A statistical distribution of digitized energy data for a single radioisotope.

PEAK CHANNEL -- The channel number closest to the CENTROID of a radioisotope's energy distribution.

PERIPHERAL DEVICE -- A device external to the main unit.

PHA -- See Pulse Height Analysis.

POLE/ZERO -- A method of compensating the preamplifier's output signal fall-time and the amplifier's shaping time constant. Its use improves the amplifier's high count rate RESOLUTION and overload recovery.



PULSE HEIGHT ANALYSIS -- Distribution of event amplitudes versus frequency of event occurrences.

R

RANGE, ADC -- The full-scale address of the ADC's assigned MEMORY segment.

REGION OF INTEREST (ROI) -- A user-determined area of the MCA display which contains data of particular interest, such as a PEAK.

RESOLUTION -- The ability of an amplifier or a detector to differentiate between two PEAKs that are close together in energy. Thus, the narrower the peak, the better the resolution capability. Measured as FWHM.

ROI -- See Region of Interest.

S

SCA -- Single Channel Analyzer -- recognizes events (pulses) that fall between two voltage limits (an LLD and a ULD) set by the operator. Outputs a LOGIC PULSE for each event recognized. In an MCA, the pulse enables ADC conversion.

SEQUENCE -- A series of MCA functions (steps) listed in the order of performance.

SHV -- Safe High Voltage connector.

SPECTRUM -- A distribution of radiation intensity as a function of energy or time.

STRIP -- An MCA function where an operator specified fractional part of the data in one section of MEMORY is subtracted from the data in another section of memory. The data in the first section remain unchanged.

SUBTRACTIVE DATA ACQUISITION -- Incoming data is subtracted from the data in the MEMORY.

T

TAG NUMBER -- A data identifier assigned by the MCA or by the operator.

TRANSFER -- An MCA function where data in one section of MEMORY can be copied into another section of memory. The data is not cleared from the first section.

TRUE TIME -- Real (clock) time.

TTL PULSE -- See Logic Pulse.

U

ULD -- Upper Level Discriminator. A comparator that outputs a LOGIC PULSE when the ADC's input exceeds the comparator's preset reference voltage level.

V

VERTICAL FULL SCALE -- The maximum amount of data that can be shown on the display's vertical axis.

VFS -- See Vertical Full Scale.

W

WRAPPED DISPLAY -- Data exceeding the VERTICAL FULL SCALE will be displayed at the bottom of the screen and will increase from there. Compare CLIPPED DISPLAY.

Z

ZERO, ADC -- The control which aligns the ADC's zero energy CHANNEL with the MEMORY's channel zero.

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BASIC WARRANTY

Equipment manufactured by Canberra Industries, Inc. is warranteed against defects in materials and workmanship for a period of twelve months from date of shipment, provided that the equipment has been used in a proper manner as detailed in the instruction manuals. During the warranty period, repairs or replacement will be made at Canberra's option on a return to factory basis. The transportation cost, including insurance to and from Canberra, is the responsibility of the Customer except for defects discovered within 30 days after receipt of equipment where shipping expense will be paid by Canberra to and from Canberra.

The customer must obtain an authorized customer service return number before returning any equipment to the Canberra factory. *Compliance with this provision by the customer shall be a condition of this warranty.* In giving shipping instructions, Canberra shall not be deemed to have assumed any responsibility or liability in connection with the shipment.

The Canberra Basic Warranty applies only to equipment manufactured by Canberra which is returned to the factory. If equipment must be repaired at the customer's site, the actual repair labor and parts will be provided at no charge during the warranty period. However, travel expenses to and from the customer's site, (travel time labor, and living expenses while on site), shall be paid by the customer unless an On-Site Warranty Option has been purchased. This option may only be purchased prior to shipment of the equipment to the customer.

The express warranties set forth herein are the only warranties with respect to the products, or any materials or components purchased from others and furnished by Canberra, and there are no other warranties, expressed or implied. The warranty of merchantibility is expressly limited as herein provided and all warranties of fitness are expressly disclaimed and excluded. Canberra shall have no liability for any special, indirect or consequential damages, whether from loss of production or otherwise, arising from any breach of warranty hereunder or defect or failure of any product or products sold hereunder.

EXCLUSIONS

Warranty service is contingent upon the proper use of all equipment and does not cover equipment which has been modified without Canberra's written approval or which has been subjected to unusual physical or electrical stress as determined by Canberra Service personnel. Canberra Industries shall be under no obligation to furnish warranty service (preventive or remedial): (1) if adjustment, repair or parts replacement is required because of accident, neglect, misuse, failure of electrical power, air conditioning, humidity control, transportation, or causes other than ordinary use; (2) if the equipment is maintained or repaired or if attempts to repair or service equipment are made by other than Canberra personnel without the prior approval of Canberra.

This warranty does not cover detector damage caused by neutrons or heavy charged particles. Damage from these causes is readily identifiable as described in the manual accompanying each detector. Be windows are susceptible to mechanical damage and to corrosion from harsh or humid environments. Such damage is not covered by the warranty.

Although Canberra may frequently supply, as part of systems, equipment manufactured by other companies, the only warranty that shall apply to such non-Canberra equipment is that warranty offered by the original manufacturer, if any.

Canberra will, upon request, offer, as an option, warranty coverage for non-Canberra equipment such as computers and peripherals sold as part of a system supplied by Canberra. Quotations on this coverage may be obtained by contacting Canberra Customer Service or any of our sales staff.

SOFTWARE

Canberra warrants software media from defects discovered within 30 days after receipt.

Canberra assumes no responsibility for user-written programs or programs published as part of information exchange in Canberra periodicals.

Engineering assistance for software development is available and can be contracted through the Sales Department.

INSTALLATION

Installation of equipment purchased from Canberra shall be the sole responsibility of the customer unless the installation is specifically contracted for at the prevailing Canberra field service rates. To insure th installation after receipt of equipment, it is recommended that installation be contracted for at the time the equipment is ordered.

ON-SITE WARRANTY OPTION

The On-Site Warranty Option provides for free on-site warranty work (Canberra pays all travel and living expenses) within the first 90 days after delivery of equipment to the customer. If installation is ordered from Canberra, the 90 day period commences upon completion of the initial installation. After the 90 day period, labor and materials used on site will still be covered by the basic warranty, but the customer shall pay for all travel expenses—travel time labor and living expenses incurred for any on-site service.

A maintenance contract may be purchased covering the period after the 90 days on-site warranty period, or after initial installation of the equipment. This is to be contracted through Canberra Customer Service.

REPAIRS

Any Canberra-manufactured instrument no longer in its warranty period may be returned, freight prepaid, to our factory for repair and realignment. When returning instruments for repair, contact the Customer Service Department for shipping instructions and an Authorized Customer Service Return Number.

All correspondence concerning repairs should include the Model number and a description of the problem observed.

Once repaired, all equipment passes through our normal preshipment checkout procedure. Return shipping expense on out-of-warranty repairs will be charged to the customer.

For instruments out of warranty, the customer must supply a purchase order number for the repair before the item will be returned.

SHIPPING DAMAGE

Shipments should be carefully examined when received for evidence damage caused by shipping. If damage is found, immediately no Canberra and the carrier making delivery, as the carrier is normally responsible for damage caused in shipment. Carefully preserve all documentation to establish your claim. Canberra will provide all possible assistance in processing damage claims.

RETURN SHIPMENTS

Canberra Customer Service Department must be notified in advance if equipment is to be returned for any reason. Canberra can suggest the best means of shipping and will be able to expedite the shipment in case it is lost or delayed in transit.

The customer must obtain an authorized customer service return number before returning any equipment to the Canberra factory. *Compliance with this provision by the customer shall be a condition of this warranty.* In giving shipping instructions, Canberra shall not be deemed to have assumed any responsibility or liability in connection with the shipment. Care should be exercised in packing equipment for return. The customer is responsible for adequate packing to prevent damage in shipment. If the original shipping container is not available and the customer does not have the means to provide a suitable container, Canberra can provide a container for a fee.

Equipment should be returned to your area service center or to Canberra, Meriden. For shipment from outside the U.S., our shipping address is:

Canberra Industries, Inc.
c/o M.C.B. Customhouse Brokers, Inc.
Bradley International Airport
Air Cargo, Complex A
Windsor Locks, CT 06096 U.S.A.

SERVICE AND SERVICEABILITY

Canberra has gone to great lengths to insure that the instruments provided are functionally modular and therefore easy to service. In addition to modularity, Canberra has embarked on an extensive System Service Program to provide a totally responsive service capability. Complete Service Contracts with special arrangements for 24 hour response weekend standby services are available from Canberra. For a detai description of our Customer Service Program, please contact our Systems Service Department in Meriden, Connecticut, U.S.A.