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**4620 MULTIGAS ANESTHESIA MONITOR ANALYZER
HOST INTERFACE FOR THE IBM XT/PC/AT**

SOFTWARE GUIDE

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1. A "*" or ";" character causes the program to ignore text to the end of the line and may be used freely throughout the file for comments or remarks. If the comment character is the first non-white space on the line, the entire line will be ignored.
2. Any number of spaces or tabs (white space) may be used around configuration items.
3. A "\$" directly preceding a numeric value causes the program to treat it as an hexadecimal value. (e.g. \$100 translates into 100 hex or 256 decimal).

The following example may be used as a guide for creating a configuration file or modifying an existing one.

```

*
* HOST4620 CONFIGURATION FILE EXAMPLE
*
HALOIBMG.DEV ✓ * (01) graphics device driver path name
1 ✓ * (02) graphics device mode (1=CGA 640x200 BW)
HALOEPSN.PRN ✓ * (03) printer device driver path name
-1 ✓ * (04) printer orient.: (0=horz, 1=vert,
-1=default)

1 2 * (05) printer x scale multiplier
1 + * (06) printer y scale multiplier
$3F8 ✓ * (07) serial port (COM1=0x3F8, COM2=0x2F8)
4 ✓ * (08) irq (COM1=4, COM2=3)
19200 ✓ * (09) default baud rate (9600, 19200)
7 * (10) default auto enable (1=XMIT, 2=STATUS,
4=ZERO)

$1000 * (12) driver receive queue size ($400- $FFFF)
250 * (13) start up idle timeout delay
3000 * (14) reset overrun timeout delay
4000 * (15) bench command timeout delay
2000 * (16) idle timeout monitor delay
1500 * (17) return status monitor delay
2000 * (18) xmit continuous monitor delay
5000 * (19) self auto-zero monitor delay
3 * (20) reset retries before driver halts
0 * (21) maximum command retries
4 * (22) default xmit sample rate (1=full speed)
10 * (23) packets processed/schedule call
$FF * (24) autozero purge time (0-37.5, $00-$FF)
$10 * (25) device id ($10 fixed)
0 * (26) N/A
300 * (27) default N20 tag value (0-1000)
0 * (28) N/A
380 * (29) default CO2 tag value (0-1026)
320 * (30) default O2 tag value (0-1000)

*
* END OF CONFIGURATION FILE
*

```

Modifications to this file should only be attempted by experienced users of the program. Erroneous information can cause

program failure. The configuration described above should operate properly on any IBM XT/PC/AT with a CGA, EGA or VGA graphics adapter, Epson printer and COM1 serial port.

5.0 Program Startup

The HOST4620 program requires the following files to begin operation:

HOST4620.EXE	The main executable program.
HOST4620.CFG	System Configuration file.
HALOIBMG.DEV	CGA graphics device driver.
HALOEPSN.DEV	(or equivalent) printer driver (optional).

Assuming that HOST4620.CFG has been properly set up (refer to the section entitled "Configuration File"), the operator should type the following command from the MSDOS shell to begin the program:

```
C:\HOST4620>HOST4620 [HOST4620.CFG]
```

The optional [HOST4620.CFG] parameter will cause HOST4620 to look for the configuration file in an alternate directory.

HOST4620 will load HOST4620.CFG before entering graphics mode. If any errors occur, a message will be displayed and the program will be terminated.

If enabled in the configuration file, the program will automatically initiate continuous transmission, status updates and autozero requests with the bench. The screen should illuminate all status indicators and a real time graph display of all four gas channels should begin immediately.

If this does not occur, the following guidelines should be used for troubleshooting:

1. Check all physical connections to the bench and make sure that the program is configured for the proper serial port. An RS232 line analyzer between the host computer and the bench communications card should indicate pulses every second or so from the host, if the port and interrupt type is correct and automatic operation is enabled.
2. Verify that the baud rate is consistent with the jumpering on the bench communications board. Check the analyzer documentation for more details.
3. Some older versions of the bench communications card require handshake lines (DTR/RTS) to enable communications. If you are using one of these devices, verify that the RS232 cable supports these lines.

4. If automatic operation has not been enabled in the configuration file, the program may be in an idle state waiting for input from the operator. Refer to the section entitled "Auto Enable and Channel Select" to manually enable these functions.
5. If the DEVICE ID code stored in the bench is not consistent with the value in the configuration file, the bench will ignore all requests from the program. Repowering the bench should reset it to the default address (\$00).

5.1 Main Screen Display

The display is divided into fixed and variable regions. The variable regions include the top most function label line and the large center region which by default is occupied by the gas channel graph display. These two regions are discussed in detail later in this manual. The fixed regions are visible and operational at all times and are discussed in the following sections.

5.1.1 System Status Region

The left side of the screen displays the current system status from the bench if automatic status is enabled or a single RETURN STATUS response is received. If status is not being updated, these indicators may display erroneous values. The status indicators are defined in the following sections.

5.1.1.1 MODE

This indicator reflects the operational mode of the bench. The possible values are "normal", "waittag", "waitspan", "autozero" and "autospan". Refer to the analyzer documentation for more details.

5.1.1.2 STAT/XMIT/ZERO

These indicators reflect the auto enable state of the host program and are not part of the bench's standard status header. Refer to the "Configuration File" and "Auto Enable and Channel Select" sections of this manual for more details.

5.1.1.3 DRIVERS

The state of the solenoid drivers as returned in the status header is displayed as sample/purge (DRIVER 1) and room/scrub (DRIVER 3) respectively.

5.1.1.4 CONT

This indicator should be "on" if continuous transmission is enabled.

5.1.1.5 PUMP

This indicator reflects the state of the pump motor solenoid.

5.1.1.6 COMP

This indicator should be "on" if compensated gas values are being returned in the xmit packet. Uncompensated mode is used for diagnostic purposes only to monitor the raw A/D values of the gas channels.

5.1.1.7 REF

This indicator should be "on" if the normal o2 channel is selected. An "off" condition indicates that the diagnostics reference channel is selected.

5.1.1.8 AUTOZERO

There are three indicators in this field which reflect the current auto zero state of the bench, as returned in the status header.

The first field indicates the current auto zero interval which may be "awaiting", "30 secs", "5 mins", or "30 mins".

The second field indicates auto zero "elapsed" state and will be normally blank if auto zero is currently valid.

The third field indicates and temperature shift (temp), reference drift (ref) or both (temp/ref). This field is normally blank if these exceptions are not pending.

5.1.2 Gas Value Update Region

The five gas value boxes just below the graph region are updated alternately from left to right every half second during continuous transmission. The left most box will update with the current agent selected as long as status is enabled (either automatically or manually).

A single asterisk "*" will appear after the gas channel name if the data check flag was set in the current xmit packet.

If continuous transmission is not in effect and a single XMIT 1 DATA SET response is received from the bench, all of the gas value fields and data check flags will be updated.

This region is always visible on the display.

5.1.3 Driver Response Region

All driver responses as described in the 4620 Analyzer manual are updated as they occur in the lower, center region of the display, just below the Gas Value Update Region. This region displays all ACK, NAK and TMO responses from the bench. Any errors encountered while parsing receive packets (e.g. checksum errors, packet length errors etc.) will be displayed in reverse video. Specific NAK error descriptions will be displayed if possible.

This region is always visible on the display.

5.1.4 Driver State Region

The communications state of the bench is updated continuously in lower left hand corner of the screen. There are four possible driver states as described below:

1. off line Communications with the bench is INACTIVE and no requests from the host are pending.
2. on line Communications with the bench is ACTIVE and packets are being received and parsed successfully.
3. pending Communications requests to the bench are PENDING, however no responses have been received.
4. resetting Communications with the bench is pending driver reset. This state will remain in effect until communications has been successfully terminated and the program has detected an idle state.

5.1.5 Driver Baud Rate Region

The current baud rate is always visible in the bottom left region of the screen. Only 9600 and 19200 baud may be selected. The configuration file determines the default baud rate for the program which may be changed with the BAUD function discussed later in this document.

5.1.6 Console Input Region

Except for function key commands, all keyboard input to the program is prompted for in the lower, center region of the display. The basic function key commands are displayed by default in this region.

When input is required, the console input region overlaps the adjacent Driver Baud Rate and Receive Buffer Status regions and prompts the user for input. Input may be aborted with the <escape> key and accepted by pressing the <enter> key. The <backspace> key may be used to erase characters to the left of the prompt, which is indicated by a single underscore character "_". The arrow keys have no effect on input.

In addition, error messages associated with user input will be displayed in this area and usually accompanied by a warning bell. In most cases, pressing any key acknowledges the error and resets the region to it's default display.

5.1.7 Receive Buffer Status Region

The serial receive buffer status is updated every two seconds in the lower right area of the screen and is expressed as a percentage of the total receive buffer size (see the Configuration File section of this manual for more details).

If the program is running on an 8 mhz machine or less, a maximum transmission rate of 72 frames per second (19200 baud) will eventually overflow the receive buffer. If this value continues to increase, the operator should decrease the frame rate and/or baud rate until it stabilizes. Overflow will be more likely to occur if the graph display is enabled, multiple gas channels are being displayed, file capture is enabled or rapid screen changes are made.

This region is always visible on the display.

5.1.8 Real Time Clock Region

The real time clock is updated every two seconds in the lower right hand corner of the screen. This function is provided as long as the program is operating.

This region is always visible on the display.

6.0 General Function Key Commands

The following functions are globally accessible and provide control of the the display in all modes. These functions are show in the same format as they appear in the help menu.

ESC	Select	graph display
	Abort	help menu. (restore last screen)
	Abort	keyboard input
?	Display	help menu (all modes)
Right Arrow	Move	label select right one item
Left Arrow	Move	label select left one item
<Num 5>	Rotate	label selections
<Enter>	Select	label function
Home	Move	to top of current menu
End	Move	to bottom of current menu
PgUp	Scroll	up to top of current menu
PgDn	Scroll	down to bottom of current menu
Up Arrow	Move	menu select up one item
Down Arrow	Move	menu select down one item
<Enter>	Select	menu function

6.1 Graph Control Function Keys

F1	Decrease Increase	frames/second (set capture speed)
	Increase	playback speed
F2	Decrease	vertical SCALE multiplier
F3	Increase	vertical SCALE multiplier
F4	Increase Decrease	frames/second (set capture speed)
	Decrease	playback speed
F5	Center	vertical OFFSET
F6	Decrease	vertical OFFSET
F7	Increase	vertical OFFSET
F8	Default	SCALE and OFFSET
<Space>	Pause	graph display (non-destructive)

7.0 Function Labels

Most program functions are implemented through the function labels on the uppermost line of the display and are accessible in all modes. The left and right arrow keys move the label selection across the screen horizontally. The 5 key in the center of the Num Pad, rotates the label display through seven rows of functions. The <enter> key selects a function. If the BENCH or FILE screens are visible, the Down Arrow key reactivates it.

When the labels are illuminated in reverse video (white background, black text), the functions can be controlled as described above. In center of the function label line, a single numeric value indicates the active function label set. When the BENCH or FILE screens are selected, the labels change to normal video (black background, white foreground) and the row number is hidden. In this state, the function labels are disabled and all functions keys operate on the current screen. Pressing the <escape> key will cause the function labels to be reactivated.

The following sections describe the functions of each label set as displayed in the system help menu.

7.1 Primary System Functions (1)

The Primary System Functions are the default when the program is first invoked. All of the screen select functions are included in this set.

AUTO	Toggle	XMIT/STAT/ZERO	automatic requests
BENCH	Display	bench	commands and parameters
FILE	Display	CAPTURE/PLAYBACK	status and directory
STATUS	Display	channel descriptors	and full status
CAPTURE	Toggle	CAPTURE file	(bench channel/fps)
PLAY	Toggle	PLAYBACK file	(file channel/fps)
PRINT	Print	current display	(abort operations)
EXIT	EXIT TO DOS		(abort operations)

7.2 Auto Enable and Channel Select (2)

The functions in this set toggle program enables that have no affect on the actual bench operation. The label will be displayed with a dot on either side if the function is active.

The first three functions enable and disable automatic requests to the bench. The program will maintain continuous operation of each function if enabled. The AUTO function in the Primary System Functions set serves as a "master" to these three functions.

The other five functions toggle the graph display channels (if visible), and capture/playback channels. Refer to the "FILE Operation" section of this manual for more details.

STAT	Toggle	automatic RETURN STATUS	monitor
XMIT	Toggle	automatic XMIT CONTINUOUS	monitor
ZERO	Toggle	automatic AUTO ZERO	monitor
AGE	Toggle	AGENT channel	(graph/capture)
N20	Toggle	N20 channel	(graph/capture)
CO2	Toggle	CO2 channel	(graph/capture)
O2	Toggle	O2 channel	(graph/capture)
PRES	Toggle	PRES channel	(graph/capture)

7.3 Bench Controls (3)

Commonly used bench commands are accessible through this function set, to allow bench control while viewing screens other than the BENCH screen. All of these functions are toggles and are reflected in the STATUS indicators after acknowledgment has been received.

DRV1	Toggle	PURGE/SAMPLE	(driver 1)
DRV3	Toggle	ROMM/SCRUB	(driver 3)
DRV13	Toggle	both drivers	
PUMP	Toggle	PUMP motor on/off	(sample)
COMP	Toggle	COMPENSATION	(diagnostics)
REF	Toggle	O2 REFERENCE	(diagnostics)

7.4 Secondary System Functions (4)

The first two functions in this set cause a complete driver reset and prompt the user for verification before proceeding. The other functions are duplicates of the commands found in the BENCH screen command menu.

RESET	Reset	4620 communications	
BAUD	Toggle	19200/9600 baud rate	
TEST	Request	SELFTEST	
PURGE	Enter	PURGE time	(auto zero)
AZERO	Request	AUTO ZERO	(manual)
XMIT1	Request	XMIT 1 DATA SET	(manual)
STATUS	Request	RETURN STATUS	(manual)

7.5 Auto Span Functions (5)

The Auto Span Functions provide a complete set of controls for auto span when the BENCH screen is not visible. The first four functions only toggle auto span channel enables and are independent of the normal channel select functions described in previous sections.

The other functions duplicate the bench commands found in the BENCH screen menu.

sN2O	Toggle	N2O	span enable	(auto span only)
sAGE	Toggle	AGENT	span enable	(auto span only)
sCO2	Toggle	N2O	span enable	(auto span only)
sO2	Toggle	N2O	span enable	(auto span only)
SPAN	Request	FIRST SPAN		(cocktail or seq)
TAG	Request	RECEIVE TAG VALUES		(must span first)
sRESET	Request	RESET SPAN		(factory defaults)

8.0 GRAPH Operations

The real time graph display is the default screen when the program is first invoked. The center of the graph is divided into 1, 2, 3, or 4 independent graphs depending on the channels enabled (refer to the "Auto Enable and Channel Select" section of this manual for more details). This screen can be activated from any other screen by pressing the <escape> key several times.

8.1 Channel Display

The channel names are displayed on the left side of the graph, with corresponding scale and offset displays on the right. The Graph Control Function Keys operate on the currently selected channels.

8.2 Speed Display

The horizontal graph scale is displayed in the lower region of the graph and is represented in seconds. Adjusting the speed control function keys will cause these values to change in scale.

8.3 Graph Input Indicators

Under normal operating conditions, the left most text display in the lower region of the graph shows the current transmit rate from the bench. This value is derived as a function of baud rate and frames processed as follows:

$$\text{fps} = 72 \text{ fps} / (19200 / \text{baud rate}) / \text{packet processing rate}$$

If data capture is active, this indicator reflects the frame rate at the time capture was enabled. The speed controls will be disabled while data capture is active.

The playback speed is displayed on the right side of this region if enabled. Since playback and capture may be enabled at the same, the currently selected graph source is always highlighted in reverse video (white background, black background).

The <space> bar acts as a pause toggle in graph mode and is displayed in the center of this region when activated.

9.0 BENCH Operations

The BENCH screen is displayed when the BENCH function label is selected. All of the bench commands are available in this menu as well as a display of all variable bench parameters. The Up Arrow, PgUp, PgDn and Down Arrow keys move the selection bar and scroll the menu. Pressing the <enter> key will activate the selected menu item. Most commands are executed when selected and require no further operator interaction. The following sections describe all commands with variable parameters.

9.1 Auto Zero Command

The auto zero command requires purge time to be set prior to the request. The currently displayed purge time value will be used for all subsequent auto zero requests. The default purge time may be set in configuration file and adjusted by selecting the PURGE function. The user will be prompted for input which can be a hexadecimal value between \$00 and \$FF or a decimal value between 0.0 and 37.5. The current auto zero status is visible at all times in the status region on the left side of the display.

9.2 Auto Span Command

Prior to invoking the auto span sequence, the operator must select the channels to be spanned from the Auto Span Function set. These functions provide all of the controls required to maintain auto span from any screen. Once the channels have been selected, they will remain in effect until the bench mode returns to "normal".

9.2.1 Cocktail/Sequential Span

The first auto span request will cause the following prompt to be displayed:

```
span N20 HAL CO2 O2 cocktail (Y/N)? _
```

Answering "Y" to the above prompt will cause the program to send the first auto span request to the bench with the selected channels and the cocktail bit SET.

Any other key will cause the following prompt to be displayed:

```
span N20 HAL CO2 O2 sequential (Y/N)? _
```

Answering "Y" to the above prompt will cause the program to send the first autospan request to the bench with the selected channels and the cocktail bit RESET. Any other key will abort the auto span sequence.

9.2.2 Receive Gas Values

When the bench mode changes to "waittag", the program will automatically display the following prompt:

```
send current N2O HAL CO2 O2 tag values (Y/N)? _
```

Answering "Y" to this prompt will cause the program to send the current tag values for the selected channels as displayed in the lower left region of the BENCH screen.

Any other key will cause the program to prompt for new tag values for all of the selected channels selected. The current value for each channel is displayed and will be accepted if <enter> is pressed. New values are format and range checked and the appropriate error message issued if an error is found.

```
enter N2O tag value (20.0-100.0): 30.0
```

At the end of this sequence, the program will ask to send the current values again. Pressing the <escape> key will abort the sequence. Since the bench is already awaiting tag values, reselecting the auto span command after aborting this sequence will cause the program to prompt for tag values again until the values are sent or the bench times out.

9.2.3 Span Cocktail

If cocktail span was selected as the first auto span request, the program will issue the following prompt to start spanning the cocktail mixture:

```
span N2O HAL CO2 O2 cocktail (Y/N)? _
```

Answering "Y" will cause the program to send the final auto span request.

Any other key will put the autospan sequence in an idle state. Since the bench is already awaiting the last span request, reselecting the auto span command after aborting this sequence will cause the program to prompt again until the span request is satisfied or the bench times out.

56 30 wa
8
38

9.2.4 Span Sequential

If sequential span was selected as the first auto span request, the program will issue the following prompt to start spanning the first gas selected:

span N2O (Y/N)? _

Answering "Y" will cause the program to send an auto span request for the selected gas.

Any other key will put the autospan sequence in an idle state. Since the bench is awaiting a span request, reselecting the auto span command after aborting this sequence will cause the program to prompt again until the span request is satisfied or the bench times out.

This sequence will continue until all of the channels selected are spanned.

9.2.5 Auto Span Errors

Since the auto span sequence is a timed process in the bench and the sequence of events is critical, the program checks for consistency at all times based on the state of the bench mode.

The following messages will be generated automatically in the input region if an error occurs or the sequence completes:

1. "no span channels selected": this error message will be issued if no channels have been enabled before an auto span related request is attempted.
2. "channels already selected": this error message will be issued if an attempt is made to change the active span channels after auto span has been initiated.
3. "auto span sequence error": this error message is caused by an erroneous mode change at any time during program operation. Further auto span requests will be inhibited until the bench is times out or is reset.
4. "auto span timed out": if the bench changes to "normal" mode before completing the auto span sequence at any point, this message will be issued. The operator must reactivate the auto span sequence from scratch after this error.
5. "auto span complete": a bench mode transition from "autospan" to "normal" indicates completion of the auto span sequence.

9.3 Reset Span Command

The Reset Span Command uses the currently selected span channels for the bench request mask. Invoking this command will produce the following prompt:

```
reset span N2O HAL CO2 O2 (Y/N)? _
```

Answering "Y" to this prompt will cause the program to issue a RESET SPAN request to the bench for the displayed channels. Pressing any other key will abort the command.

9.4 Receive Gas Values Command

The gas tag values may be modified and sent regardless of the bench mode and program auto span state at the time. If the bench is not awaiting tag values, it will respond with the appropriate error message. Since the auto span sequence of events is critical, this command will be normally invoked by the program automatically.

9.5 Receive Device Id Command

The device id of the bench can be any value between 0 and 255 or \$00 and \$FF (hexidecimal). The program will prompt for a new device id as illustrated below:

```
enter new device id (0-255): _
```

A leading "\$" causes the program to treat the input as a hexidecimal value. A new device id is made active, only after the request is acknowledged by the bench.

10.0 FILE Operations

Continuous data may be captured to a disk file and played back at any time during program operation. Because of the inherent multitasking structure of the program, both operations may occur simultaneously (on different files). Data files of type ".BIN" are maintained in the MSDOS path structure and include a sixteen byte definition header at the beginning, followed by gas values of the selected channels. The files are maintained in a binary format to optimize disk usage. The header describes the active transmission rate and channels selected. The header is checksummed to protect the system from loading erroneous data.

10.1 Working Directory

Selecting the FILE function causes the program to prompt for the current working directory on the bottom line of the display. The default directory is used if a single <enter> is pressed as illustrated in the example below.

Path: C:\HOST4620*.BIN

Any legal MSDOS path name may be entered with or without a file type. If no file type is included, the program defaults to "*.BIN". Otherwise, the FILE screen will be displayed with a directory listing of the current path and the capture/playback status of the program. File headers may be examined by selecting an item in the list using the menu control function keys.

If playback mode is inactive, the header of the currently selected file will be displayed in the PLAYBACK region of the screen. This file will also become the default play back file name for subsequent play back requests.

10.2 Capture Mode

Selecting the CAPTURE function causes the program to prompt for a capture file name. The default capture file will be loaded if the operator responds with a single <enter>. If no path is included, the current working directory is used. If no file type is included, the current file type or the default ".BIN" is used.

A capture file may be opened at any time during program operation. The active frame rate and selected graph channels will be latched at this time and will remain in effect until the file is closed. The capture file name will be displayed in the lower right region of the screen in reverse video while file capture is active.

Selecting the CAPTURE function a second time closes the capture file.

10.3 Playback Mode

Selecting the PLAY function causes the program to prompt for a playback file name. The default playback file will be loaded if the operator responds with a single <enter>. If no path is included, the current working directory path is used. If no file type is included, the current type or default type ".BIN" is used.

A playback file may be opened at any time during program operation. The active frame rate and selected graph channels are loaded from the file header and the graph is reset accordingly (if enabled). The playback file name will be displayed in the lower left region of the screen in reverse video while the file is open.

Selecting the PLAY function a second time closes the playback file.

11.0 STATUS Operations

Selecting the STATUS function produces a full screen display of all status indicators as returned in the bench status header. Automatic status requests must be enabled to get a continuous update on the display. Since most of the bench commands are accessible to the operator through the function labels, the status screen can be used to monitor status transitions while performing auto span, auto zero, etc..

12.0 HELP Operations

The system help menus may be requested at any time during program operation, by pressing the "?" key. The PgUp and PgDn keys rotate the help menus sequentially. Individual screens may be scrolled with the Up and Down Arrow keys.

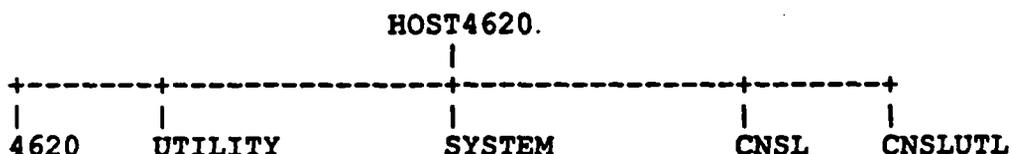
The first two menus describe general function keys commands. The other five correspond to the function label set number at the top of the screen. Rotating the function label sets with the Num Pad 5 key will cause the help screens to rotate in synchronization.

The screen active before help was invoked, will be restored when the <escape> key is pressed.

13.0 Software Maintenance

The HOST4620 program was developed using Borland International's TURBOC C Compiler version 1.05 and IMSI's TURBOHALO graphics library version 2.26a. The TURBOC Compiler is distributed with an editor, compiler, linker and makefile facility, which are all that is required to maintain the source code.

The source and resulting object files are organized in a predefined hierarchical directory structure and may reside at any level of the MSDOS path structure. All file references are relative to the HOST4620 root directory, which contains the batch generation command files and the resulting executable object code (HOST4620.EXE).



13.1 Release Diskettes

The HOST4620 program is released on one quad density, 1.2 megabyte diskette. All source and executable files have been included as follows:

\HOST4620	BATCH GENERATION AND RUNTIME FILES
HOST4620.EXE	HOST4620 executable program file
HOST4620.CFG	HOST4620 program configuration file
HOST4620.DEF	HOST4620 system include file definitions
MAKE4620.BAT	HOST4620 batch generation command file
HOST4620.MAK	HOST4620 makefile command definitions
HOST4620.LNK	HOST4620 link list
\HOST4620\SYSTEM	MAIN SYSTEM SOURCE AND DEFINITIONS
CONFIG.C	System configuration handler
CONFIG.H	
HOST4620.C	Main program entry point
STDDEFS.H	Standard 'C' definitions
SYSDEFS.H	System definitions
\HOST4620\CNSL	CONSOLE DISPLAY SOURCE AND DEFINITIONS
AUTOSPAN.C	Autospan state machine
AUTOSPAN.H	
BENCH.C	Bench screen handler
BENCH.H	
BENCHLIB.C	Bench screen support functions
BENCHLIB.H	
CNSL.C	Main console task
CNSL.H	
CNSLFUNC.C	Console function key routines
CNSLFUNC.H	
CNSLRESP.C	4620 driver response routines
CNSLRESP.H	

FILE.C	File screen handler
FILE.H	
FILELIB.C	File screen support functions
FILELIB.H	
GRAPH.C	Graph screen handler
GRAPH.H	
GRAPHLIB.C	Graph control library routines
GRAPHLIB.H	
HELP.C	Help screen handler
HELP.H	
STATUS.C	Status screen handler
STATUS.H	
UPDATE.C	Gas update display handler
UPDATE.H	

\HOST4620\CNSLUTL DISPLAY UTILITY SOURCE AND DEFINITIONS

DRAWLIST.C	Graphics draw list control routines
DRAWLIST.H	
INPUTMSG.C	Keyboard input control routines
INPUTMSG.H	
LABELMSG.C	Function label control routines
LABELMSG.H	
MSGLIST.C	Menu list control functions
MSGLIST.H	
TEXTMSG.C	Text object control functions
TEXTMSG.H	

\HOST4620\UTILITY INTERRUPT/UTILITY SOURCE AND DEFINITIONS

COMDRV.R.C	Communication interrupt driver
COMDRV.R.H	
HALO.H	TURBOHALO definitions
HALOIF.C	TURBOHALO interface library
HALOIF.H	
KYBD.C	Keyboard interrupt driver
KYBD.H	
TIMER.C	Real time interrupt driver
TIMER.H	
UTILITY.C	Utility functions
UTILITY.H	

\HOST4620\4620 4620 DRIVER SOURCE AND DEFINITIONS

4620.C	Main 4620 driver task
4620.H	
4620CMD.C	4620 command request handler
4620CMD.H	
4620STAT.C	4620 status handler
4620STAT.H	
4620XMIT.C	4620 xmit response handler
4620XMIT.H	

13.2 Software Installation

The following sections describe the installation of the HOST4620 development software on an IBM XT/PC/AT.

To create a development environment for the HOST4620 program, make a backup of the original distribution diskette and install the TURBOC and TURBOHALO software as outlined in documentation for these products.

The location of the C compiler and HALO graphics libraries, are critical to the build process and should be tested before attempting to regenerate the software.

After proper installation of the development tools, follow these steps:

1. Copy the distribution diskette using the MSDOS XCOPY command available with MSDOS 3.00 or later:

```
C:\>XCOPY A:\HOST4620 C:\HOST4620 /S
```

XCOPY will create and/or overwrite the directories and copy the files respectively. If XCOPY is not available, the directories will have to be created manually with MKDIR and copied one subdirectory at a time with COPY.

2. The file HOST4620.LNK included on the distribution diskette, contains several references to the location of the TURBOC and the TURBOHALO libraries. Both directories should be setup as logical MSDOS drives using the SUBST command for location independence. Make sure these are consistent with the directives in HOST4620.LNK, or the compiler will be unable to find them. The TURBOC directory has been assigned the logical drive T: and the TURBOHALO directory has been assigned H: on the distribution diskette. These assignments may be placed in the AUTOEXEC.BAT file or invoked at the command line as in the following example:

```
C:\HOST4620>SUBST T: C:\TURBO\TC  
C:\HOST4620>SUBST H: C:\TURBO\HALO
```

To enable drive designators up to Z:, you must place the following command in your CONFIG.SYS file and reboot the system:

```
LASTDRIVE=Z
```

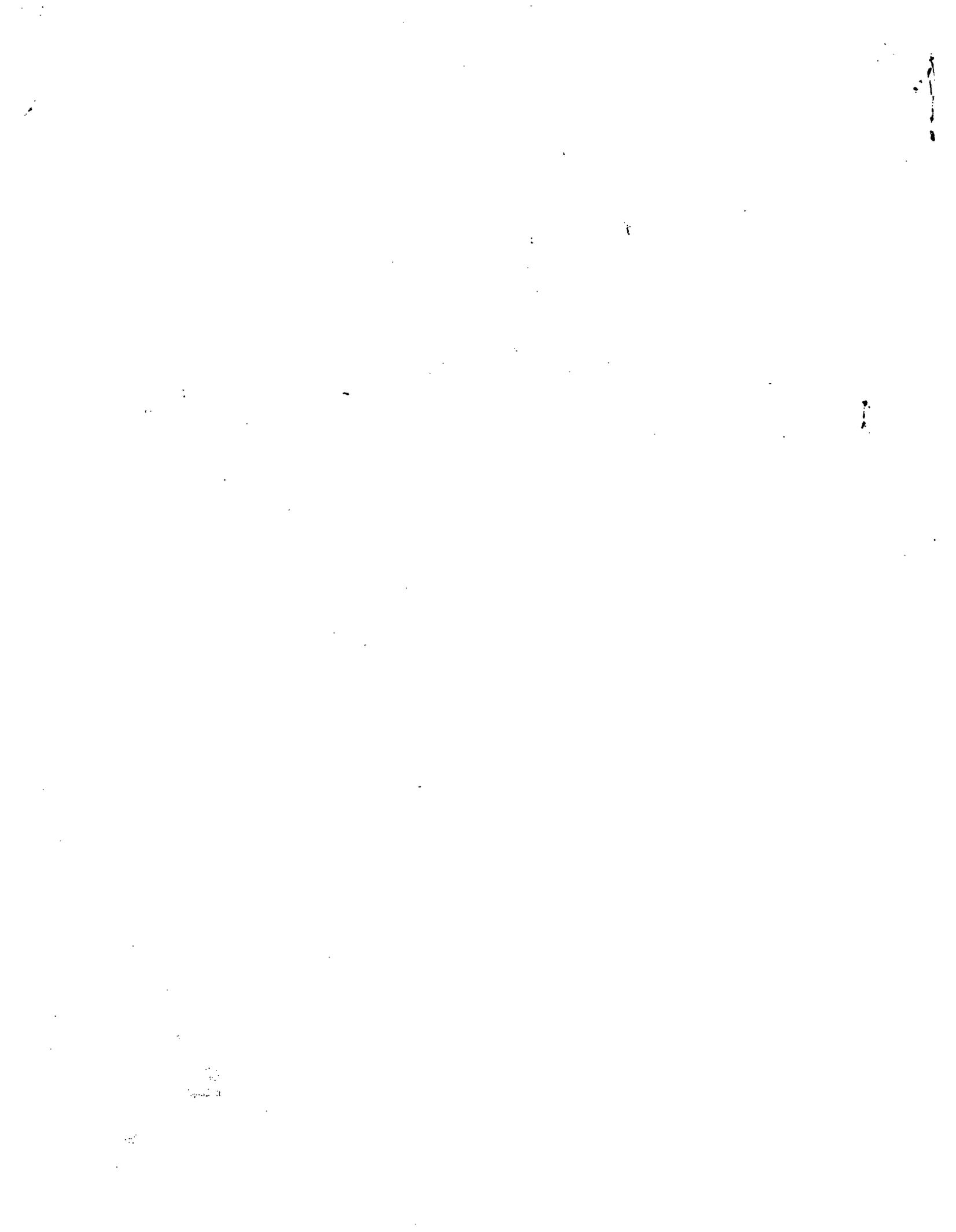
13.4 TURBOC Batch Generation

The program is distributed in source and executable files and will only require regeneration if a source file is modified. To change a source file, edit the file using TURBOC's TC editor or similar, and invoke the TURBOC MAKE program using the following command:

```
C:\HOST4620>MAKE4620
```

MAKE4620.BAT invokes the TURBOC MAKEFILE facility and redirects all console messages to file HOST4620.RES. MAKE.EXE executes commands in HOST4620.MAK and performs complete generation of the program as required. MAKE checks the time and dates of all pertinent files to determine which files to recompile and link.

If MAKE returns immediately without executing the compiler or linker, the files can be assumed to be up to date. To override this logic, simply erase the .OBJ files you wish to regenerate or HOST4620.EXE to relink. The final output of the batch generation process is HOST4620.EXE.





GAS EQUIPMENT TECHNOLOGY GROUP

UNITS : SCCM WATER DATE : 07-19-1991
TUBE NUMBER : 601(E200) TYPICAL STD CONDITIONS : 1 ATMOS. &70 DEG F
FLOAT NUMBER : 002 GAS TEMPERATURE : 70 DEG F
FLOAT MATERIAL: GLASS DELIVERY PRESSURE : 0 PSIG

Table with 8 columns: SCALE READING, FLOW RATE, SCALE READING, FLOW RATE, SCALE READING, FLOW RATE, SCALE READING, FLOW RATE. It contains 30 rows of data points ranging from 150.0 to 111.0 on the left and 70.0 to 31.0 on the right.



GAS EQUIPMENT TECHNOLOGY GROUP

UNITS : SCCM AIR DATE : 07-18-1991
TUBE NUMBER : 601(E200) TYPICAL STD CONDITIONS : 1 ATMOS. & 70 DEG F
FLOAT NUMBER : 002 GAS TEMPERATURE : 70 DEG F
FLOAT MATERIAL: 316 ST. STL. DELIVERY PRESSURE : 0 PSIG

Table with 8 columns: SCALE READING, FLOW RATE, SCALE READING, FLOW RATE, SCALE READING, FLOW RATE, SCALE READING, FLOW RATE. It contains 20 rows of data points.



GAS EQUIPMENT TECHNOLOGY GROUP

UNITS : SCCM WATER DATE : 07-19-1991
TUBE NUMBER : 601(E200) TYPICAL STD CONDITIONS : 1 ATMOS. &70 DEG F
FLOAT NUMBER : 002 GAS TEMPERATURE : 70 DEG F
FLOAT MATERIAL: 316 ST. STL. DELIVERY PRESSURE : 0 PSIG

Table with 8 columns: SCALE READING, FLOW RATE, SCALE READING, FLOW RATE, SCALE READING, FLOW RATE, SCALE READING, FLOW RATE. Rows range from 150.0 to 111.0.



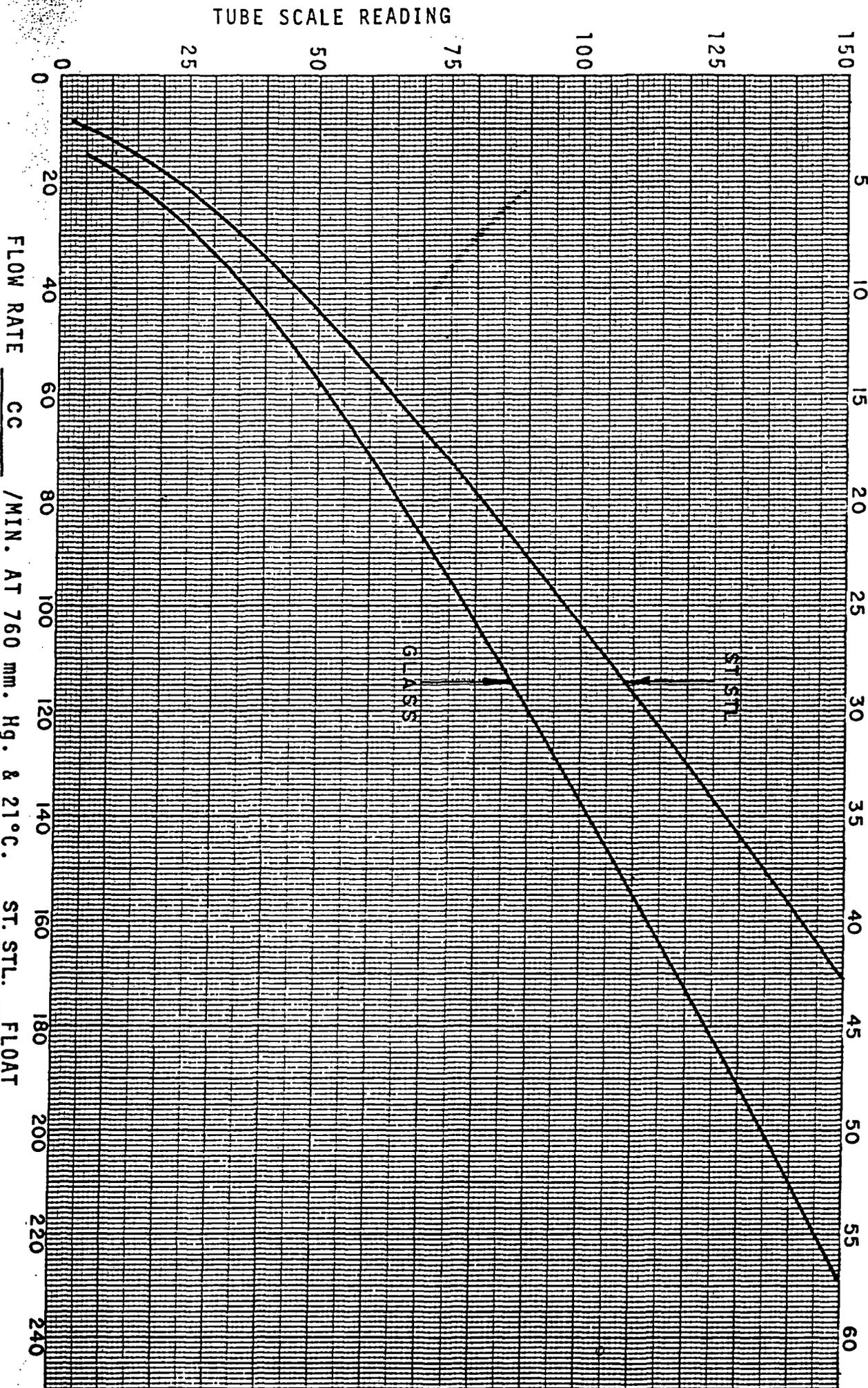
MATHESON GAS PRODUCTS

FLOWMETER CALIBRATION - Scale Reading vs. Flow Rate
Calibration With Both Floats Simultaneously

AIR

FLOW RATE CC /MIN. AT 760 mm. Hg. & 21°C. GLASS FLOAT

TUBE NO. 600(E100)
SER. NO. TYPICAL



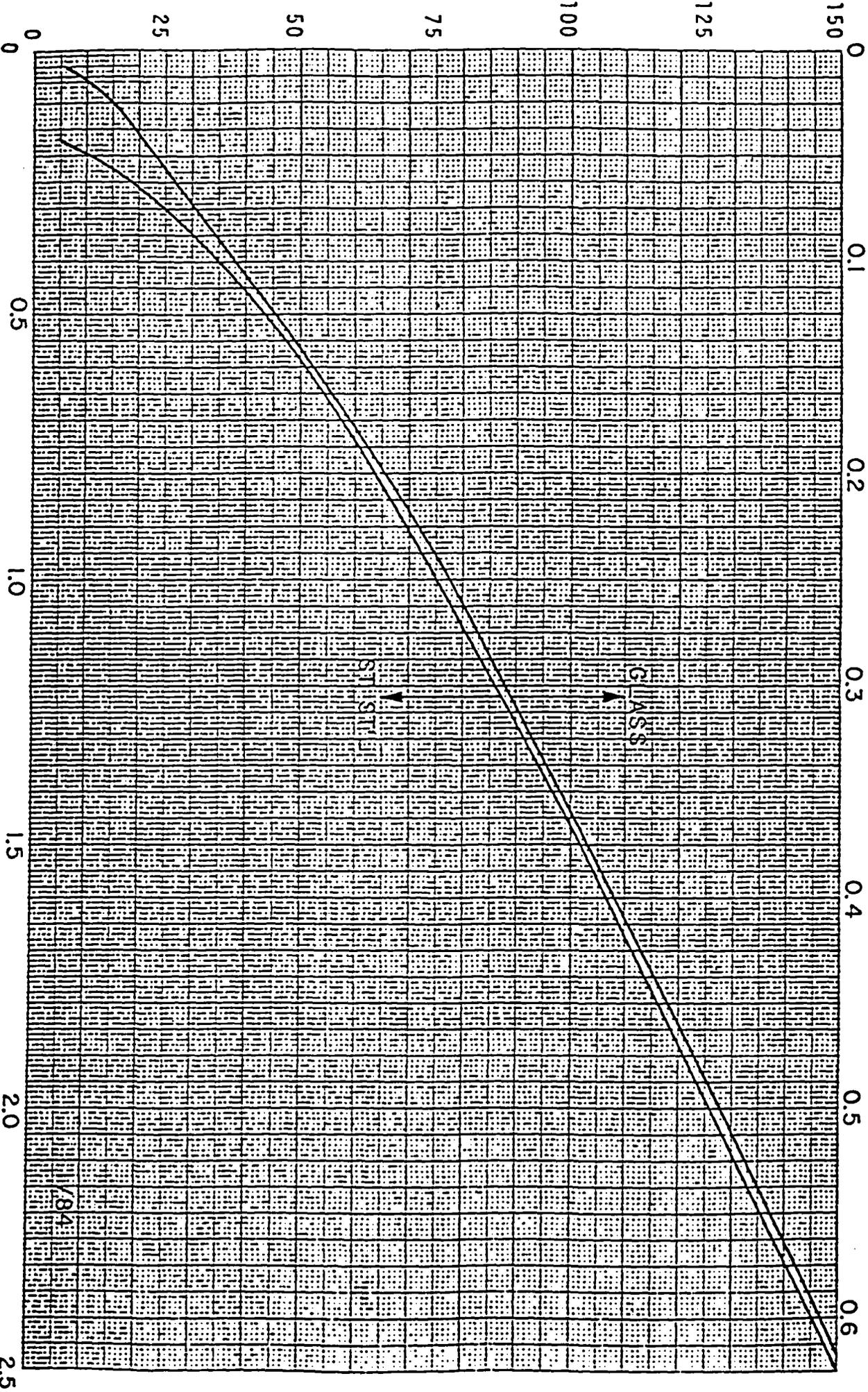


FLOWMETER CALIBRATION - Scale Reading vs. Flow Rate
Calibration With Both Floats Simultaneously

--- FLOW RATE CC /MIN. AT 760 mm. Hg. & 21°C. GLASS FLOAT

WATER
TUBE NO. 600
SER. NO. TYP

TUBE SCALE READING - MILLIMETERS



FLOW RATE CC /MIN. AT 760 mm. Hg. & 21°C. ST. STILL FLOAT



GAS EQUIPMENT TECHNOLOGY GROUP

UNITS : SCCM AIR DATE : 07-18-1991
TUBE NUMBER : 601(E200) TYPICAL STD CONDITIONS : 1 ATMOS. & 70 DEG F
FLOAT NUMBER : 002 GAS TEMPERATURE : 70 DEG F
FLOAT MATERIAL: GLASS DELIVERY PRESSURE : 0 PSIG

Table with 8 columns: SCALE READING, FLOW RATE, SCALE READING, FLOW RATE, SCALE READING, FLOW RATE, SCALE READING, FLOW RATE. It contains 30 rows of data points.

1B414
Kliff

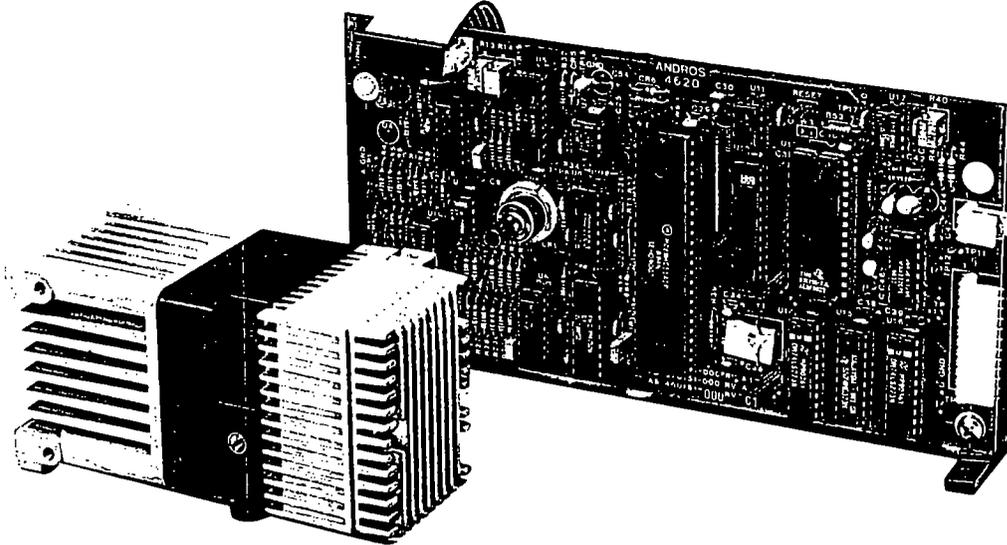
ANDROS®
ANDROS INCORPORATED

MODEL 4620
DIGITAL
CO₂ / N₂O ANALYZER

INTERFACE / SERVICE MANUAL
891107-000

Rec'd 30 July 91

David Kleinfeld
Room 1C-463
ATT Bell Laboratories
600 Mountain Avenue
Murray Hill, N.J. 07974



Catalyst Research
Oxygen Sensor
Part # 472062
410 -
~~301~~-256-2400 No!
Judy & Tina

Telodyne
213-283-7181
Boris Rybkin

MODEL 4620
DIGITAL
CO₂ / N₂O ANALYZER

George Shapiro (Company President)

↓
Don Madison

John Zorn x5797

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510

5857

Peter Chan - Technical Support



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SECTION 1

GENERAL INFORMATION

1.1 SCOPE OF THIS MANUAL

This manual describes the Andros Model 4620 digital gas analyzer. The 4620 is used primarily in gas analyzer systems for medical applications that can benefit from the unit's high level of performance. The gases analyzed by the 4620 are CO₂ and N₂O.

This manual is written for a number of audiences, including the following:

- Host hardware designer - provides analyzer specifications and data on pneumatic and electrical interface with the host system.
- System programmer- describes the 4620 command set, communications protocol, and typical applications.
- Process Engineering - describes suggested incoming inspection and initial calibration procedures.
- Service personnel - includes extensive description of periodic maintenance, adjustment and troubleshooting.

The first three sections of this manual are primarily a product overview, including theory of operation. The next three sections are technical in nature, describing Interface, Operation and Communications Protocol. The last section describes inspection and troubleshooting procedures.

Section 8 (Optional Hardware) contains information on the 4862 subsystem, which contains a gas analyzer, a pneumatics assembly and a power supply. This subsystem is offered to customers who wish to simplify integration of the gas analyzer components into their system.

Finally, the Appendixes describe the 4620 command set and other programming information.

1.2 INITIAL INSPECTION

When you receive the product, inspect it visually. Check for damage that may have occurred in transit, particularly for bent, loose or broken components.

Packaging: Do not destroy shipping containers. Andros containers are reusable and an adequate supply should be kept for future use.

Insurance Claims: Insurance is the customer's responsibility. If any damage occurs during shipping, contact the carrier immediately as well as the Andros Customer Service Manager.

Long-term Storage: Before putting the Model 4620 into long-term storage, perform an incoming inspection of the unit to verify performance (see Section S). The analyzer should be stored in its original reusable container.

1.3 MAINTENANCE PHILOSOPHY

The 4620 requires little maintenance. Gas calibration is required periodically, and the sample cell needs to be replaced if it becomes contaminated. The 4620 should run trouble free if these operations are performed. If servicing is required, Andros defines four OEM maintenance levels:

Levels of Maintenance and Repair: OEM users of the 4620 analyzer fall into one of the following levels depending on the technical level of their maintenance personnel and facilities. Andros' training seminars provide the necessary information for an OEM user to achieve the desired maintenance level as defined in the contract.

Level 1: This level allows the customer to perform incoming inspection, in-process evaluation, or field service diagnostics to determine whether an analyzer or subsystem is operational. The customer can replace the analyzer or subsystem but performs no further troubleshooting of the units.

Minimum training is required, usually 8 hours or less. Most of Andros' customers start at this level. Many continue at this level for the duration of their contracts and beyond.

Level 2: The second level allows the customer to diagnose a fault to the major assembly level. Parts and major assemblies that can be replaced at this level include: For analyzers, the chopper motor, source, sample cell, pump, solenoid valve, and some printed circuit boards. For subsystems, the power supply, the pneumatics assembly, and the analyzer.

Level 2, continued: With the IR source being the single exception, all Level 2 components are removeable and replaceable using common hand tools. Use of a soldering iron is not required.

Approximately 16 to 20 hours of classroom training and "hands on" experience are required. Some of Andros' customers have chosen to repair to Level 2 for certain components and not others, such as the chopper motor in the 200 Series analyzers.

Level 3: This level allows diagnosing and replacing most components on any analyzer or subsystem. All parts can be replaced except those that would require the unit to be re-characterized (factory calibrated). This includes approximately 98% of the faults found in these units. Performing a factory calibration very expensive and is not practical for the majority of Andros customers. Therefore, this is the most extensive level of repair presently available to the customer.

All parts listed in the Andros Service and Spare Parts manual can be replaced at this level. The parts that cannot be replaced at this level include: Parts that are directly involved with A/D conversion or servo gain control, optical filters and detector circuitry for certain types of IR detectors. In addition, certain memory devices that contain analyzer-specific information, such as EEROM and NVRAM devices, cannot be replaced at this level. These devices may exist as stand-alone devices or may be contained in microprocessor packages.

This is the level to which most of our European customers become trained.

Level 4: At Level 4, any part can be replaced and the unit can be re-characterized. This level is presently performed only at Andros facilities. Factory calibration of Andros' digital products requires specialized equipment. Although this process could theoretically be performed by the customer, it is not practical to do so. In order to maintain uniform performance from unit to unit, the process would have to be identical to the Andros procedure in every respect.

Characterizing an analyzer requires binary and "cocktail" gas blends, and involves writing specific analyzer constants to non-volatile memory. Andros uses automated equipment to perform this calibration, although a manually-operated station could be used. The cost of an automated test stand would be approximately \$20K to \$30K, which is not justified for field populations under 2000 units. A manual calibration would require about 2.5 hours per unit, in addition to the time required to diagnose and repair the unit. For most customers, labor costs make this option impractical.

1.4 FACTORY REPAIRS

The Andros factory provides repair service both as a warranty obligation and as a maintenance service to customers. All Andros repair work carries a minimum 90-day warranty.

Warranty Repairs: Unit is repaired or replaced free of charge.

Out-Of-Warranty Repairs: May be handled in the following ways:

- **Exchange at Fixed Fee:** Whole units or major sub-assemblies are exchanged at a fixed rate.
- **Factory Rebuild:** Andros rebuilds the entire unit, updates it to the latest revision level, and calibrates it to Andros specifications. A one-year warranty is issued. There is a fixed rate for a factory rebuild.
- **Special Repair:** Repairs are made on a time and materials basis. A minimum charge is required.

Returning Material: To return a Model 4620 for repair or replacement, first call the service depot for a Return Material Authorization (RMA) number. Then, pack the model 4620 in an Andros reusable container and send it to the depot. Include a note stating the RMA number and the reason for the return. If a new purchase order is required for the work, please include the new purchase order number.

Andros has two service depot locations:

Andros Service Depot (U.S.)
Andros Incorporated
2332 Fourth Street
Berkeley, CA 94710
Telephone 415-849-5700
FAX 415-849-5849

Andros Service Depot (Europe)
Mess- & Pruetechnik
Aemmenmattstrasse 3A
CH - 3123 Belp, Switzerland
Telephone 41-31-813091
FAX 41-31-813191

1.5 TRAINING

Andros offers its customers two separate training programs in classroom situations:

1) Regularly scheduled classes at Andros, and 2) Custom classes, held at Andros or at the customer site. Class scheduling, cost, and student enrollment procedures are described in the following sections.

Additional information on class scheduling and enrollment can be obtained by contacting Andros' Customer Training Department in Berkeley, California, during regular business hours. The telephone number for training information is (415) 849-5700.

1.5.1 Classes in the U.S.

Training classes are available for any of the Andros products. The courses cover field service level maintenance, and include a complete, detailed presentation of the product with emphasis on theory of operation, troubleshooting and repair. For most products the presentation is to both the component and small-part level.

Regularly Scheduled Classes: Regularly scheduled classes are presented at the Customer Training Center at the Andros facility in Berkeley, California. Class duration is two days, and the cost is \$175 per student. Transportation, lodging, meals and all general expenses incurred by the student are not included in the course cost and are the responsibility of the student or the student's employer.

Custom Classes: Custom classes may be held either at Andros in Berkeley, California, or at any customer site within the United States. These classes are designed to meet a customer's specific training requirements. A classroom situation can be a highly desirable and cost effective means of meeting these needs.

The exact content and length of a course is determined by a conference between the customer and the Andros Customer Training Department, and is based upon the specific needs of the customer. Andros requires the following for custom classes:

- Custom or customer site classes depend on Andros instructor availability. Therefore, Andros' Customer Training Department requires 30 to 60 days lead time to schedule and develop the content of custom classes.
- Class size is limited to twelve (12) students.
- For custom classes held at Andros facilities, all tools and test equipment required to present the classes are provided by Andros. For classes held at the customer's site, these items, including Andros products used during the instruction, must be provided by the customer.
- Consult Andros for a cost estimate of custom or customer site classes. The cost includes an instructor fee of \$280.00 per day (including travel days, if applicable) plus all transportation, lodging, meals and other reasonable expenses incurred by the instructor. A purchase order must be received or other financial arrangements made prior to course dates.

Andros provides all necessary technical manuals and other required training aids.

1.5.2 Classes in Europe

For classes in Europe, please contact the Andros European Sales Office listed in Section 1.8.

1.6 CUSTOMER SUPPORT

Information updates: Andros products are constantly being improved. Change information will be issued as Technical Bulletins or as changes to this manual. If any information given in this manual differs from that in an earlier source, the Andros Customer Service department is available to help resolve the difficulty.

Technical Support: Technical design assistance is available from Andros' Customer Support Engineering staff.

- Identification and location of hardware
- Identification of source material for design assistance
- Start-up assistance or evaluation
- Planning of spare parts program

An Andros Technical Support Engineer is available at our Berkeley corporate office to answer customer's telephone inquiries on technical questions. A response will usually be made within 24 hours. Before calling, it is recommended that the customer:

- Follow the Troubleshooting Procedure (Section 7.3)
- Have the following information available:

Phone-in Assistance Checklist	
1. Company	_____
2. Date	_____
3. Call Number	_____
4. Model Serial No.	_____
5. Date purchased	_____
6. End-user application	_____

1.7 REGULATORY APPROVAL

Andros is registered with the Federal Drug Administration as a manufacturer of medical instruments. Also, the Model 4620 conforms to FDA standards of Good Manufacturing Practices (GMP). Any modification to the Model 4620 must be made in accordance with FDA guidelines.

1.8 INQUIRIES AND ORDERS

All inquiries and orders are dealt with as promptly as possible. For price and delivery information, please contact the Andros Sales Department at one of these locations:

ANDROS INCORPORATED
2332 Fourth Street
Berkeley, CA 94710

Phone: (415) 849-5700
FAX: (415) 849-5849
Telex: 171751

ANDROS EUROPE
Heinz A Studiger
Ramlstrasse 50
8001 Zurich/ Switzerland

Phone: 0041 1 2528140
Telex: 58125

SECTION 2

PRODUCT OVERVIEW

2.1 DESIGN GOALS

The 4620 provides near mass spectrometer performance in a unit that is small enough to be held in one hand, and at approximately one-tenth the cost of a mass spectrometer. In addition, fast response time allows end-tidal patient breath analysis.

2.2 FEATURES AND OPTIONS

High accuracy: The 4620 uses digital techniques to provide high accuracy and ease of use to the system designer. Gas concentration outputs are fully linearized and do not require look-up tables as did analog designs.

Patented zero technique: Andros was the first to recognize that zero drift is most often caused by changes in the overall gain of the analyzer, including the optical path. Therefore Andros analyzers use a patented zero technique that corrects zero errors by correcting the gain of the analyzer electronics. The benefit to the user is that performing a zero routine, with zero gas in the sample cell, automatically corrects gas channel calibration. Therefore the Andros analyzer remains accurate over a period of months, as compared with competitive units, which may require gas calibration several times per day.

Compensation: Compensation has been provided to make gas concentration data independent of environmental changes such as temperature and pressure. In addition, cross interference effects of N_2O and CO_2 are automatically corrected for.

Simplified status reporting: The 4620 provides full status and error reporting to the user. The analyzer reports to the user when a zero is required, and allows the user to monitor all aspects of the analyzer operation. A new communication protocol simplifies status reporting.

Ease of communication: The user communicates with the 4620 over a single serial communication link. The interface is RS232 compatible. A command set consisting of 20 commands allows the user to obtain gas concentration data from the 4620 and to initiate various operations such as calibration and zero.

Subsystems available: Andros also offers the Model 4862 subsystem, providing all necessary components to perform gas concentration measurement. This subsystem consists of the 4620 Analyzer and the 1401 Pneumatics Assembly. Together these components simplify the process of integrating the analyzer into the host system. Information on the subsystem is located in Section 8 of this manual (Optional Hardware).

Please contact the Andros Customer Service Department for ordering information regarding the 4862 subsystem.

Summary of 4620 features:

- Capnometry and N₂O measurement capability
- Small size
- Low cost
- Reports concentration directly
- High accuracy
- Infrequent gas calibration
- Immune to environmental changes
- Full status and error reporting
- Serial communications standard
- Complete subsystem available

2.3 TYPICAL APPLICATION

The following diagram shows how the 4620 is integrated into a typical gas analyzer system for medical applications:

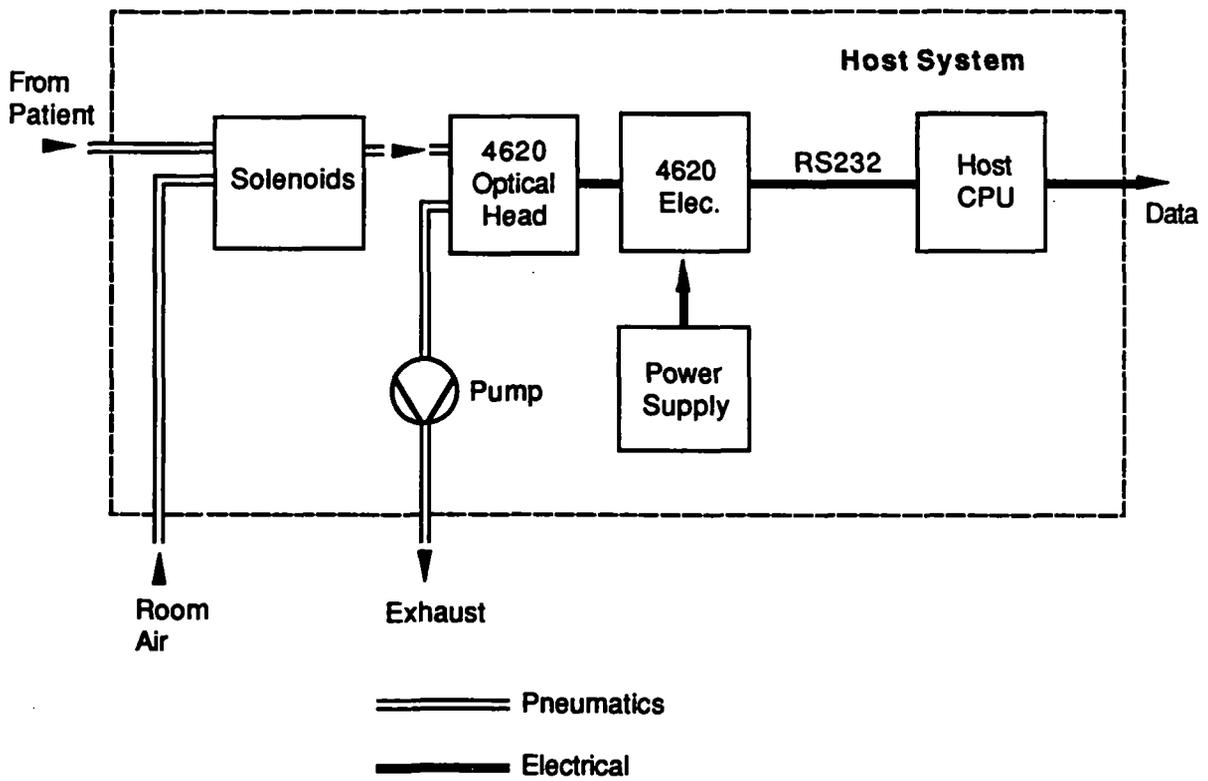


Figure 2-1. Block Diagram, Typical Application

2.4 MAIN SPECIFICATIONS

Measurement Ranges:

CO₂: 0 to 76 Torr (0 to 10 %)

N₂O: 0 to 100 %

Accuracy:

<u>Channel</u>	<u>Range</u>	<u>Accuracy</u>	<u>Resolution</u>
CO ₂ (Torr)	0 to 20 Torr	1 1.0 Torr	0.1 Torr per bit
	20 to 40 Torr	1 1.5 Torr	"
	40 to 60 Torr	1 2.0 Torr	"
	60 to 76 Torr	1 2.5 Torr	"
CO ₂ (%)	0 to 2.63 %	1 0.13 %	.01 % per bit
	2.63 to 5.26 %	1 0.20 %	"
	5.26 to 7.89 %	1 0.26 %	"
	7.89 to 10.00 %	1 0.33 %	"
N ₂ O	0 to 50 %	1 3.0 %	0.1% per bit
	50 to 70 %	1 5.0 %	"
	70 to 100 %	1 7.0 %	"

Noise:

<u>Channel</u>	<u>Noise</u>
CO ₂ (Torr)	0.5 Torr
CO ₂ (%)	0.66 %
N ₂ O	3.0 %

Notes:

- Noise is measured with 100% dry N₂ flowing through the sample cell and purge port at 1 ml per minute.
- When shown as a percent, Accuracy and Noise specifications are absolute; that is, they represent percent gas concentration.
- Accuracy and Noise are measured under the following test conditions:
 - % Test environment is held constant and within the limits specified below. Cooling is provided.
 - % Analyzer is powered up from cold start and allowed to warm up for 15 minutes.
 - % Analyzer transmits continuous channel data.
- Accuracy is determined by calculating the statistical mean of any 10 second block of data.
- Noise is defined as six standard deviations for any 10 second block of data.

Measurement Interference:

The effect of the presence of interfering gases shall be:

H ₂ O (95 % R.H.):	0.1 % relative, maximum
3 % Halothane:	0.1 % relative, maximum
7% Enflurane:	0.1 %relative, maximum
7% Isoflurane:	0.1 %relative, maximum

Environment:

	<u>Operating</u>	<u>Storage</u>
Temperature:	+59 to +113° F (+15 to +45 C)	-40 to +158° F (-40 to +70 C)
Humidity:	0 to 85 % RH (non-condensing)	0 to 95 % RH (non-condensing)
Altitude:	-1,000 to 7,000 ft. (-305 to 2133 M)	-1,000 to 10,000 ft. (-305 to 3048 M)

Pressure: Output is fully corrected over range of 10 - 16 PSIG (at sample cell).

Power Dissipation:

Warm up (during the the first 15 minutes of operation):	25 Watts maximum
Quiescent (after the the first 15 minutes of operation):	16 Watts maximum

Conditions: From a cold start at a uniform ambient temperature of 86° F (30° C), with power dissipation averaged over any one-second interval.

Power Supply Requirements:

Single supply voltage:	7.50 Volts minimum 16.5 Volts maximum
Peak to peak ripple:	15 % maximum (Not to exceed min and max voltage limits above)
Average current:	See power specification
Transient current characteristics:	6.0 Amps maximum (Transient currents are typically less than 1 millisecond and are repetitive in nature)

Response time:

Response to a step change of gas concentration at the sample cell inlet port. Analyzer response time is for a 10 to 90 % change in output at the flow rate indicated:

	<u>Flow Rate</u>	<u>Response time</u>
CO ₂ :	100 ml / min	110 milliseconds maximum
	50 ml / min	180 milliseconds maximum
N ₂ O:	100 ml / min	220 milliseconds maximum.

Warmup:

<u>State</u>	<u>Maximum time</u>
I/O active in Warm-up mode	1 minute
Warm-up mode status clears	5 minutes
30 Minute Zero Mode	15 minutes

Conditions: Test environment is held constant and within the limits specified herein. The analyzer reaches the above functional state within the specified maximum time after application of power from a cold start.

Sample cell volume: 20 microliters, nominal

Cooling requirements:

Ventilation of other means of cooling must be provided such that the limits below are not exceeded:

Detector heatsink temperature:	113°F (45 C) maximum
Motor case temperature:	149°F (65 C) maximum

SECTION 3 THEORY OF OPERATION

3.1 GAS ANALYSIS

Carbon dioxide and Nitrous oxide both absorb energy in the infrared (IR) region of the spectrum, although each gas has a different absorption characteristic. The amount of energy absorbed by each gas increases with concentration. Andros gas analyzers use this phenomenon to measure gas concentration.

Optical path: A sample of the gas to be identified flows through a small volume called a sample cell, as shown in Figure 3-1. A beam of infrared light is passed through the cell, and is detected by an infrared sensor.

Andros uses a Non-Dispersive Infrared approach, meaning that optical interference filters are used to transmit a different region of the IR spectrum for each gas. The filters are mounted in a rotating filter wheel so that each filter passes through the path of the beam. This technique allows a number of gases to be analyzed simultaneously.

The filter wheel is divided into five sections, and contains the following elements:

- A filter for CO₂
- A filter for N₂O
- A reference filter
- A "blank" timing filter
- A "dark level" portion of the wheel that completely blocks IR transmission

Signal processing: The infrared detector senses the fluctuating IR level, and generates a series of electrical pulses, where each pulse corresponds to a particular gas. These pulses are then amplified and processed electronically.

When a particular gas absorbs energy, its pulse height is reduced. This effect can be clearly observed on an oscilloscope connected to the detector output. The amount of pulse absorption is measured by the analyzer and the corresponding gas concentration for each channel is computed by digital circuitry.

Electronics: The electronic circuitry has a number of additional functions: First, it must control a number of parameters in the optical head such as temperature and motor speed. In addition it must maintain the proper timing relationship between the pulse data and the rotation of the filter wheel.

When performing digital calculations, it must compensate for a number of conditions that may affect the accuracy of the reported data. These conditions include environmental changes, such as pressure and temperature, and interference effects from other gases in the sample.

In an optical system, minor changes may occur in the optical transmission and the resulting pulse levels. These changes also affect accuracy, and Andros uses proprietary techniques to compensate for them. For example, the 4620 includes a reference filter in the filter wheel whose function is to provide information on the condition of the optical path.

During calibration, the 4620 uses the reference data to correct the gain of the analyzer circuitry. This calibration technique is performed with "zero" gas in the sample cell and is referred to as the Zero routine. This procedure is simpler and less expensive than using precision calibration gases, as required by other gas analyzers. The result of all these techniques is to provide accurate and stable concentration data for extended periods of time.

The following sections describe the 4620 in greater detail.

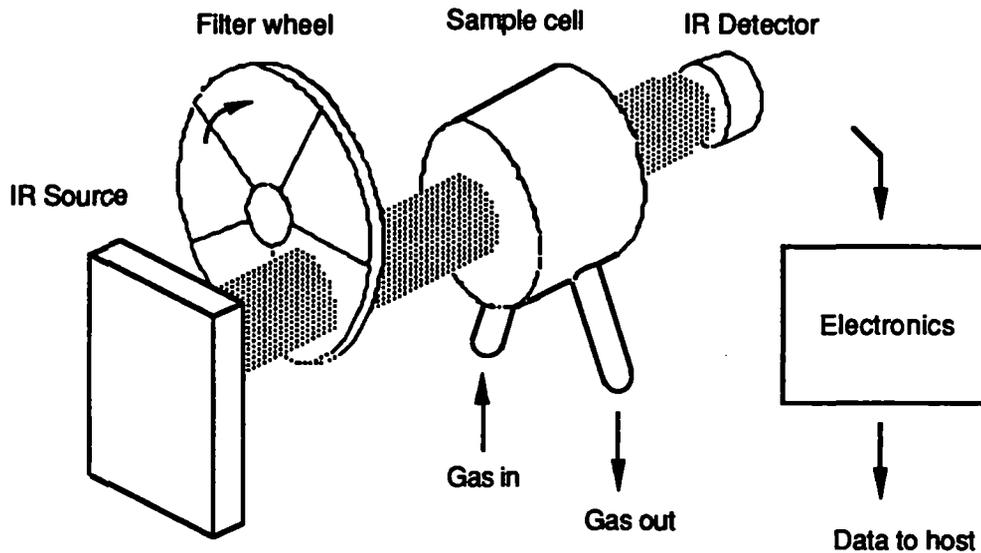


Figure 3-1. Simplified Gas Analyzer

3.2 OPTICAL ASSEMBLY

The optical assembly generates electrical pulses representing infrared absorption in a sample gas. It then amplifies these signals for use by the Processor board.

Figure 3-1 shows the main components of the Optical Assembly.

Motor: The motor rotates the filter wheel at approximately 95 ± 2 Hz (rotations per second). Therefore, the infrared absorption for each channel is measured at this rate. This rate is chosen to avoid power line and detector noise interference.

The rate of rotation is determined by a servo circuit under microprocessor control, using as feedback the optical pulses from the detector. The motor is driven with DC from a power circuit located on the SMR Board.

Infrared Source: The IR source consists of a tungsten element, encapsulated in ceramic to isolate it from the air. The Source is heated by DC from the SMR Board and emits a beam of broad-band infrared light.

The source operates at a temperature of approximately 700 to 800 C (1300 to 1500°F). For reliability, this temperature is significantly derated from its maximum rated temperature. The heat generated by the source is conducted to a heatsink, which helps to protect the motor from high temperatures.

The source voltage is tightly controlled by the main regulator on the SMR board. Although some Andros analyzers servo the source by measuring the resistance of the device, this technique is not required on the 4620.

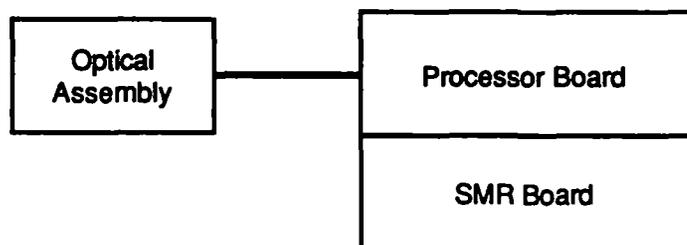


Figure 3-2. Main Components, Model 4620

Filter Wheel: The filter wheel is driven by the motor and contains a total of five elements. All of the optical filters are made from silicon.

Two of these filters are used to isolate CO₂ and N₂O. These filters permit only certain regions of the infrared spectrum to pass through the sample cell. The optical characteristics of the filters are closely matched to the wavelengths where there is infrared absorption by the gases.

The third filter passes a wavelength of light absorbed by neither of the test gases. It is referred to as the reference filter and provides an optical pulse that is proportional to full transmission through the sample cell.

The fourth filter is referred to as a "blank" since the actual passband of this filter is not critical. Its sole purpose is to generate a timing pulse that is used for motor speed control. No measurement is made in this filter position.

The last position on the filter wheel contains no filters at all. It is opaque to infrared light and is referred to as the "dark level" position. The dark level is used by the signal processing circuitry in performing gas channel calculations. The resulting waveform is also used for motor speed control. The complete waveform is shown in Figure 3-3.

The filter wheel housing is constructed of a special nylon-based plastic with high thermal insulating characteristics. It is maintained at 65 C (149°F) by a strip heater, a thermistor, and a servo circuit.

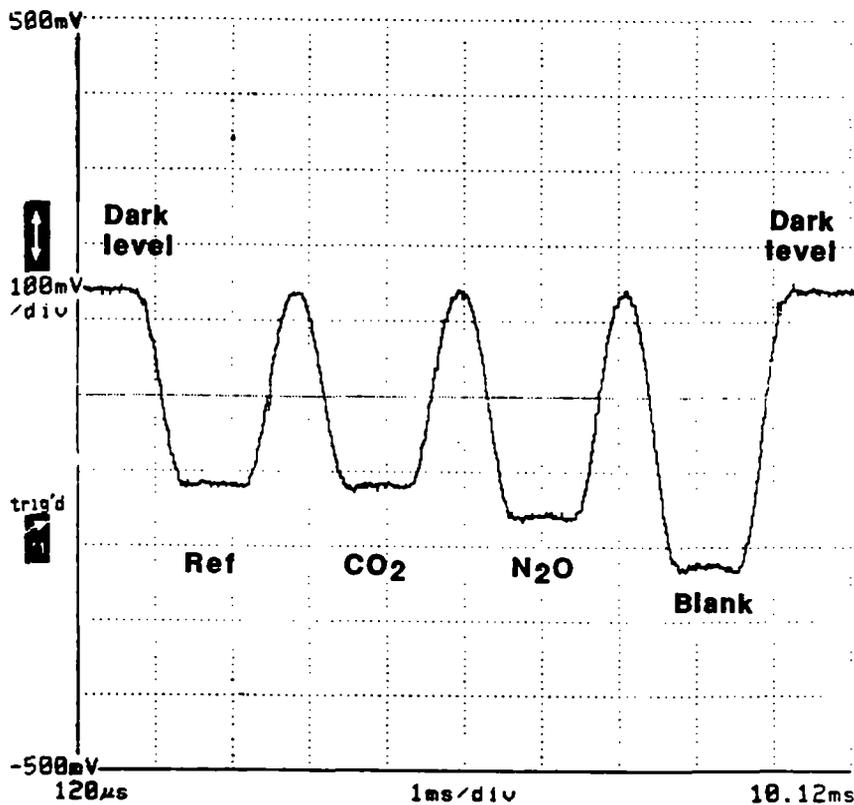


Figure 3-3. Waveform, Typical Preamplifier Output

Sample Cell: The sample cell has an inlet port and an outlet port, and contains the sample gases to be analyzed. It is constructed with sapphire windows on both ends that are ultrasonically welded to the plastic body. Cell volume for the 4620 is approximately 20 microliters.

Detector: The detector measures the energy of the infrared beam after it passes through the sample cell and generates a series of electrical pulses as shown in figure 3-3. It is a hermetically sealed lead selenide (PbSe) photoresistor, mounted on a thermo-electric cooler. The cooler maintains the detector at 5 C (41°F) by means of a servo circuit on the SMR board.

The detector is physically mounted on the preamplifier board described below.

Preamplifier Board: The preamplifier board assembly is located at one end of the optical head. It contains circuitry to amplify the detector signal, which is then sent to the Processor Board.

The gain of the preamplifier is controller by a potentiometer and is set at the factory to produce an optimum peak-to-peak voltage between the reference pulse and the dark level pulse (see Figure 3-3).

The board protrudes from housing and contains a connector for the ribbon cable that connects to the Processor Board. The board also provides attachment points for the motor leads, the filter wheel housing thermistor and heater, and the IR source.

3.4 SMR BOARD

Note: the following description refers to areas of the SMR and Processor schematics. These drawings are located in the back of this manual.

SMR stands for Switch Mode Regulator. The SMR board uses switching techniques to perform DC to DC conversion, generating the regulated DC voltages used internally by the 4620. In addition, the board supplies power to the following circuits:

- Motor Speed
- Source voltage
- Filter wheel heater
- Detector cooler
- Processor board

The SMR schematic diagram is shown in the following figure. The schematic has been divided into a number of areas, which are described as follows:

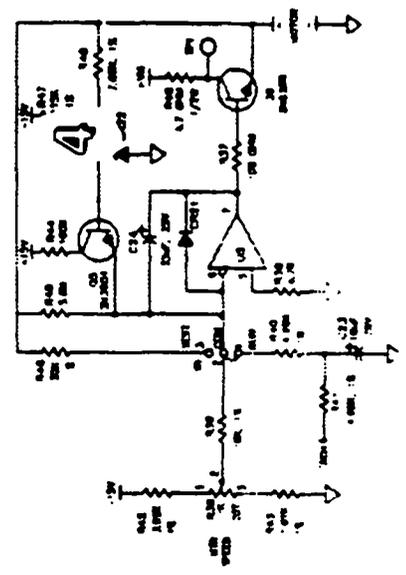
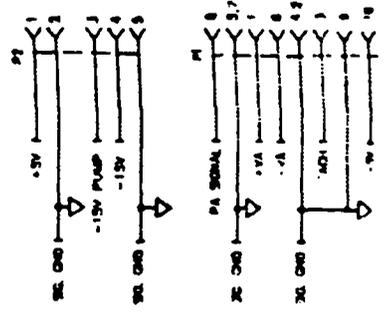
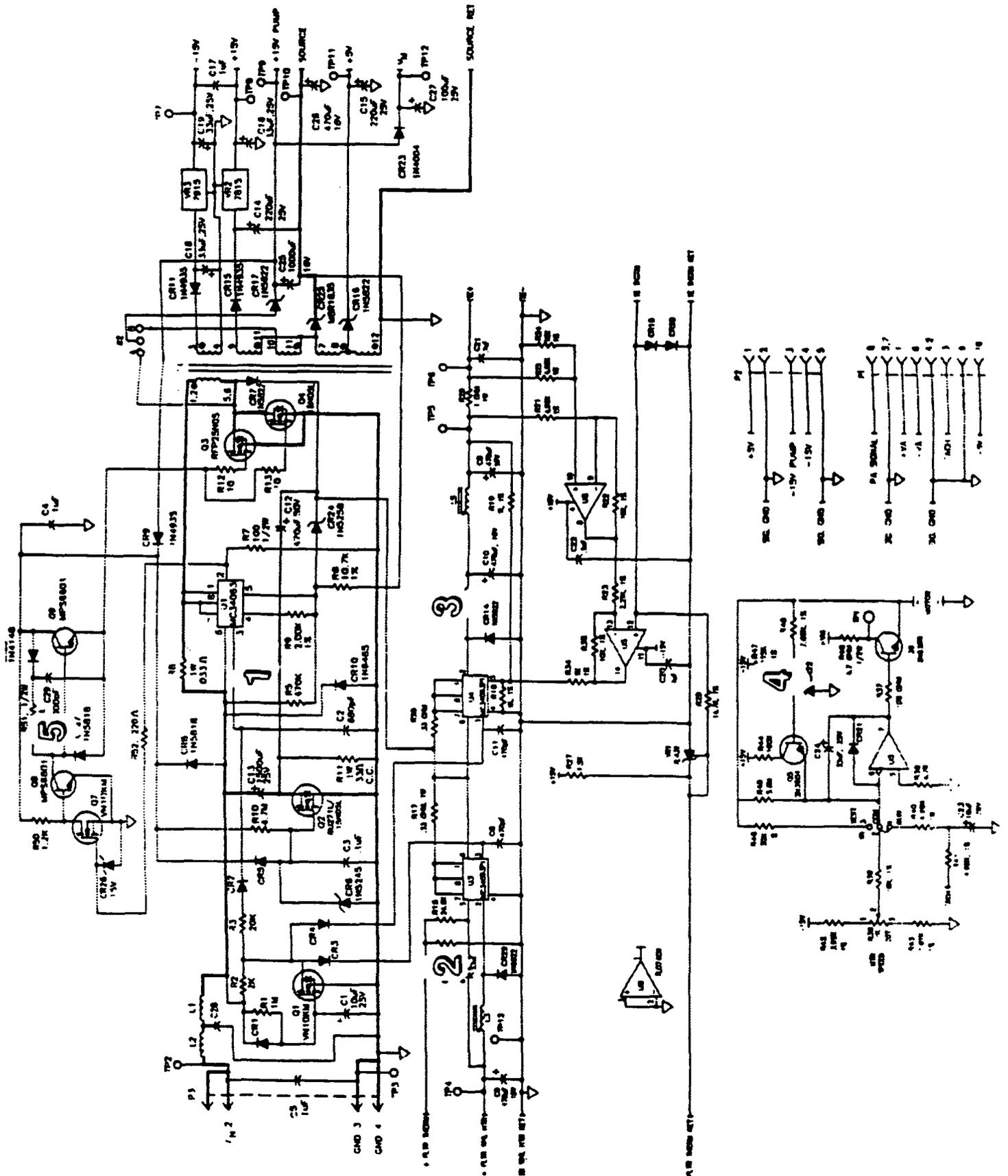
Main switching regulator: Area 1 contains the main regulator and the power switching circuitry for the 4620. This regulator generates a number of output voltages by means of transformer T1. In addition, the regulator generates an unregulated DC voltage that drives the servo circuits on the SMR board.

Integrated circuit U1 is a switching regulator that senses the voltage appearing at the "Source" output of the power supply (nominally 7.8 Volts). The voltage that drives the infrared source must be controlled most accurately of all the output voltages; therefore this voltage serves as the feedback point for the Main regulator.

The regulator IC controls the output voltage by generating a pulse width modulated signal at pin 2. This signal is conditioned by transistors Q7, Q8, and Q9, and fed to a pair of power MOSFETs operating in parallel, Q3 and Q4. These transistors in turn drive the primary winding of transformer T1.

Transformer outputs: Of the six output voltages generated by T1, two require additional regulation and four do not. The source voltage, the +5 rail, the pump voltage and the motor voltage are rectified and filtered without additional regulation. However the positive and negative 15 volt rails are controlled by linear regulator IC's VR2 and VR3. (Jumper W2 is not used by the 4620.)

The unregulated bus: This voltage is also called "Vboost" and is used to supply power to the filter wheel heater and the thermoelectric cooler circuits. It is generated by rectifying and filtering the primary voltage applied to transformer T1. Diode CR7 performs the rectification and C12 performs the filtering. The voltage is approximately 20 to 30 Volts and is supplied to pin 6 of integrated circuits U3 and U4.



Filter wheel regulator: Area 2 contains a switching regulator U3 that drives a strip heater in the filter wheel housing. Controlling the temperature of the infrared filters ensures that their optical characteristics remain stable over the entire 4620 environmental operating range. The heater is driven directly by pin 2 of the IC.

The nominal temperature of the filter wheel housing is 65 C. The circuit uses a servo technique to control temperature. A thermistor in the filter wheel housing supplies feedback to regulator U3. If the temperature decreases, U3 supplies additional power to the heater by increasing the duty cycle of the pulses to the heater.

TE cooler regulator: Area 3 contains the servo circuit that controls the thermoelectric cooler. The output to the cooler is pulse-width regulated by regulator U4, and then filtered to give a DC signal, to reduce the noise at the detector.

One half of integrated circuit U5 is a differential amplifier that senses the current to the cooler. This signal is combined with the thermistor signal from the IR detector by the other op amp in U5. The combined signal drives the regulator IC and serves as feedback for the circuit.

Motor speed circuit: Motor speed is regulated by the motor drive circuit in Area 4. It receives a pulsed signal generated by the Processor board (referred to as "Tach") that is proportional to motor speed. The circuit in Area 4 filters this signal and the resulting DC is sent to the SMR board.

Motor speed is adjusted by potentiometer R38 and jumper W1 is used during test.

Start up circuit: The left hand side of Area 1 provides soft-start capability for the SMR board. When power is applied to the board, capacitor C1 causes MOSFET Q1 to turn on slowly. This in turn causes the duty cycle of regulators U1, U3 and U4 to ramp up to full operation over a period of 3 to 6 seconds.

3.4 PROCESSOR BOARD

The Processor board schematic shown in the following figure has been divided into a number of areas. These areas are described as follows:

Preamp signal processing: Area 1 contains the analog circuitry required to process the incoming signal from the preamplifier. This signal is a series of pulses approximately 300 mV in amplitude, as shown in figure X. In order to determine the infrared absorption for each channel, Area 1 performs two primary functions: 1) normalize the incoming pulses to a particular reference level, and 2) adjust the gain or "span" of the subsequent circuitry prior to A to D conversion.

Integrated circuit U9 is a dual D to A converter that is used to set the gain of the normalization and span circuitry. The outputs from U9 appear as resistors to the analog circuitry, and their values are set digitally by the microcontroller. Figure XX shows a simplification of the analog processing circuitry.

Tach signal processing: Area 2 contains edge detection circuitry used to determine motor speed and pulse position. This circuitry generates a digital signal that is sent to the microcontroller. The signal interrupts the controller when a pulse edge is detected, and the controller records the timing information. The digital signal at Test Point 3 is shown in Figure X.

Sample and hold circuit: Area 3 contains a pair of analog switches and a voltage follower circuit used to sample the amplitude of each pulse and hold its value long enough for an A to D conversion to be performed. The microcontroller controls the closing of the analog switches, allowing the peak value of each pulse to be sampled in turn.

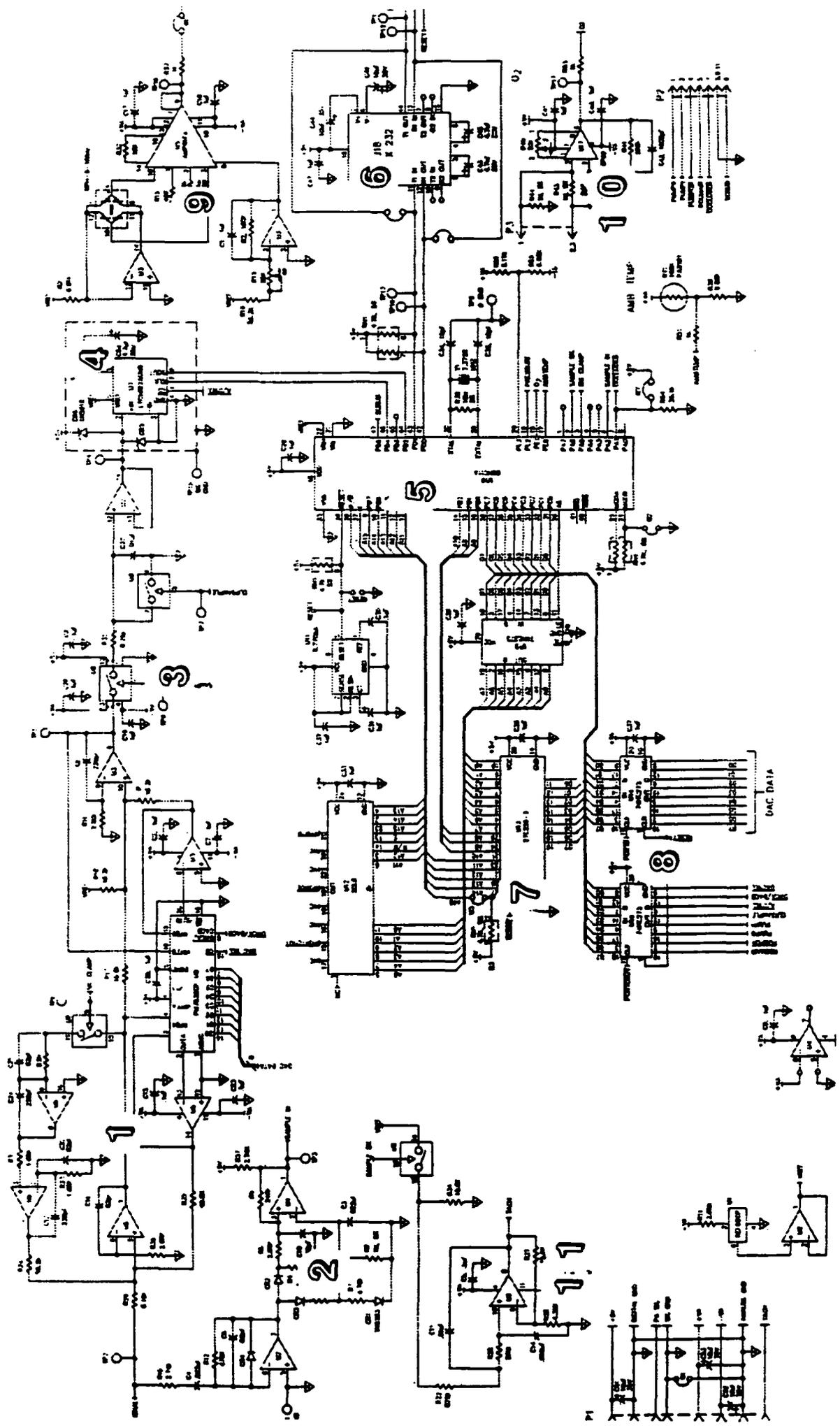
Preamp signal A to D Conversion: Area 4 is a 10 bit A to D converter. The circuit converts the amplitude of each pulse into a 10 bit binary number. The A to D device used in this circuit is designed to interface easily with the microcontroller, and is unusual in that it uses a serial data output line.

Micro controller: Area 5 is a 68HC11 microcontroller that is the heart of the 4620 processor circuitry. This device controls timing, gain settings of the analog circuitry, and various peripheral functions associated with the pneumatics components.

The controller receives pulse absorption information from the A to D converter in serial format as described. It then processes this data and generates gas concentration information, which is transmitted to the user through a serial port.

In addition, the 68HC11 contains an on-board 8 bit A to D converter that is used to measure analog voltages from the pressure and O₂ sensors. This information is used to correct the gas concentration data.

Serial output circuit: Area 6 contains a serial port driver, U18, that interfaces the microprocessor with the 4620 serial port. This IC contains an on board DC-DC voltage converter that converts 5 volt TTL signal levels to the nominal ± 12 Volt signal levels used by the RS232 standard.



Memory: In order to provide sufficient memory for the 68HC11, the 4620 uses a discrete 256K memory chip, U13, for the read-only memory (ROM) function. Additional memory functions are internal to the processor. They are random-access memory (RAM) and non-volatile memory (NOVRAM or EEROM) functions.

The discrete ROM and its associated circuitry is located in Area 7 of the schematic. U12 is a Programmable Array Logic (PAL) chip that controls the addressing to the RAM, ROM, NOVRAM and the ports. U15 is the address latch.

Micro controller data latches: Area 8 contains two IC's used to store digital data from the microcontroller. U16 holds the TTL logic signals to the pneumatics assembly and some additional signals used by the Processor board. U14 holds the digital data to the D to A converter used for normalization and span.

Pressure circuit: Area 9 contains an analog conditioning circuit for the pressure transducer. The transducer is mounted to the Processor board and is wired in a bridge configuration. A differential amplifier U5 measures the sensor voltage and generates a single-ended signal in the range of 0-5 volts for pressures in the operating range of the analyzer.

Integrated circuit U3 has two functions. One op amp energizes the pressure sensor by forcing a constant current to flow through the bridge elements. The other op amp provides a reference voltage to amplifier U5.

The circuit contains two potentiometers. R14 is used to set the output under zero pressure (vacuum) conditions. R13 adjusts the reference voltage from U3, and is used to calibrate the sensor at ambient pressure.

The resulting output voltage from U5 is supplied to the controller, which multiplexes it and drives an A to D converter internal to the 68HC11.

O2 circuit: Area 10 contains an analog conditioning circuit for the oxygen sensor. This circuit has a single adjustment, R40, to set zero offset. The output from U17 also multiplexed and digitized by the 68HC11.

Motor drive circuit: Area 11 receives a pulse width modulated signal from the controller. The duty cycle of this signal represents motor drive voltage. This signal is passed through an analog switch to a low pass filter, U2. The resulting analog voltage is passed to the SMR board, where a motor drive circuit controls power to the motor in the optical head.

SECTION 4 INTERFACE

This section describes the electrical and mechanical requirements to interface the Model 4620 with the host system.

4.1 SUMMARY OF HOST INTERFACE REQUIREMENTS

Electrical and pneumatic requirements for integrating the Model 4620 into the host system may be summarized as follows:

- DC power to P2 on the SMR board. The voltage range is +7.5 to 15 VDC. Power dissipation is 25 Watts during warm up, 16 Watts normal operation
- Serial communication lines from the host to J2 on the Processor board.
- Pneumatic lines to the sample cell, for gas delivery and return.
- (Optional) Reset line from the host to the Processor board.
- (Optional) Oxygen sensor to J3 on the Processor Board.
- (Optional) Pneumatics assembly, to control flow rate and allow introduction of zero and calibration gas into the sample cell. See Section 8 for information on the Andros Model 1401 Pneumatics Assembly. The pneumatic assembly can be controlled by 4620; connections are from J2 on the Processor board to the pneumatics assembly.

Mechanical requirements include mounting and cooling, as described in Section 4.5 below.

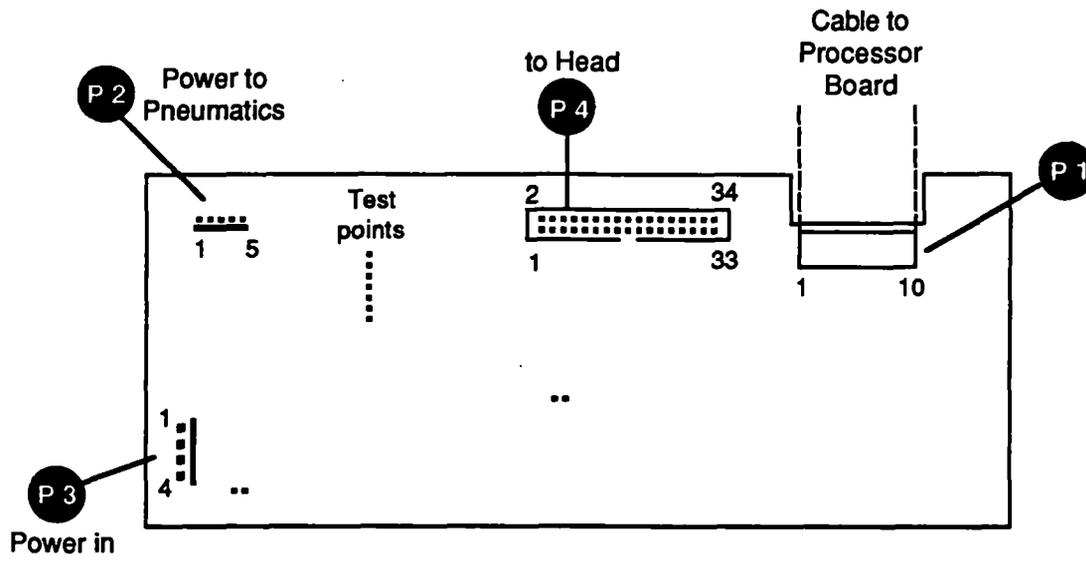


Figure 4-1. Connector locations - SMR Board

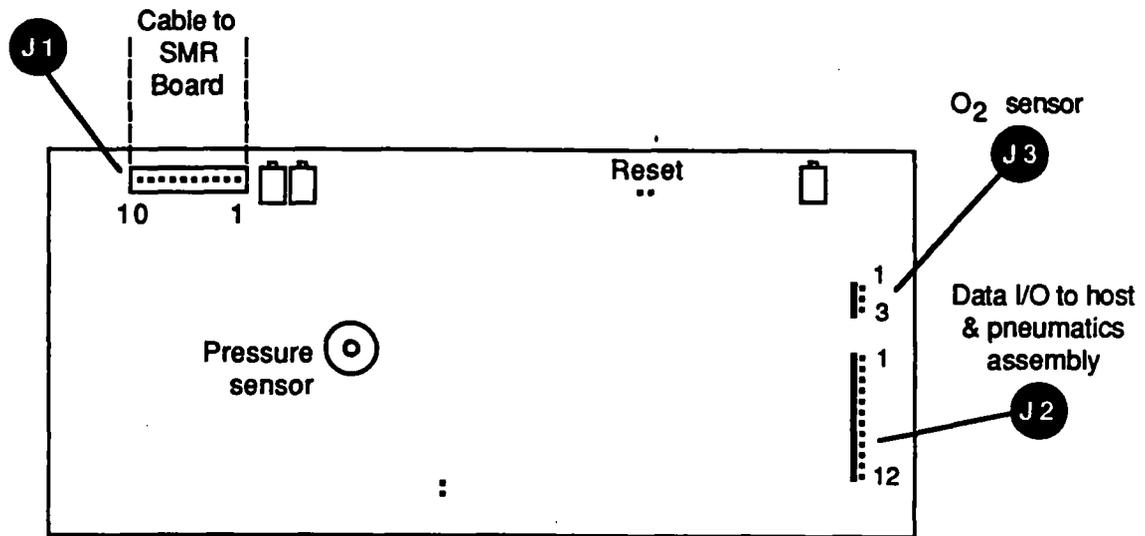


Figure 4-2. Connector locations - Processor Board

4.2 POWER SUPPLY

The Model 4620 requires a DC input voltage within the range of 7.5 to 16.5 Volts DC, and a maximum peak to peak ripple of 15%. All ripple components must be within these minimum and maximum voltage limits.

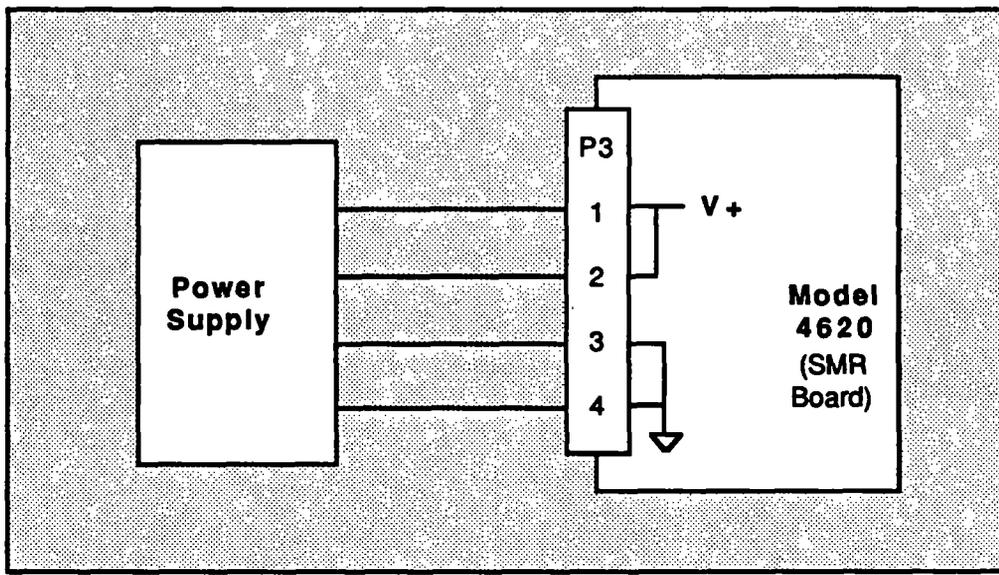


Figure 4-3. Connections, Power Supply

4.3 RESET

The reset function is accessible to the host via two locations:

- A pair of terminals located near the top of the Processor Board.
- Pin 12 of connector J2 on the the Processor Board. This connector normally transmits data to and from the host.

These sets of terminals are wired in parallel and are used to reset the 4620 microprocessor. Operation of the SMR board and the servo circuits is unaffected by the reset function. Use of these terminals is optional and is described in Section 5.2.1 of this manual.

A power-on reset occurs automatically when power is applied to the 4620. Reset can also be performed at any time by shorting or applying a logical "0" pulse to the terminals.

4.4 COMMUNICATIONS AND TIMING

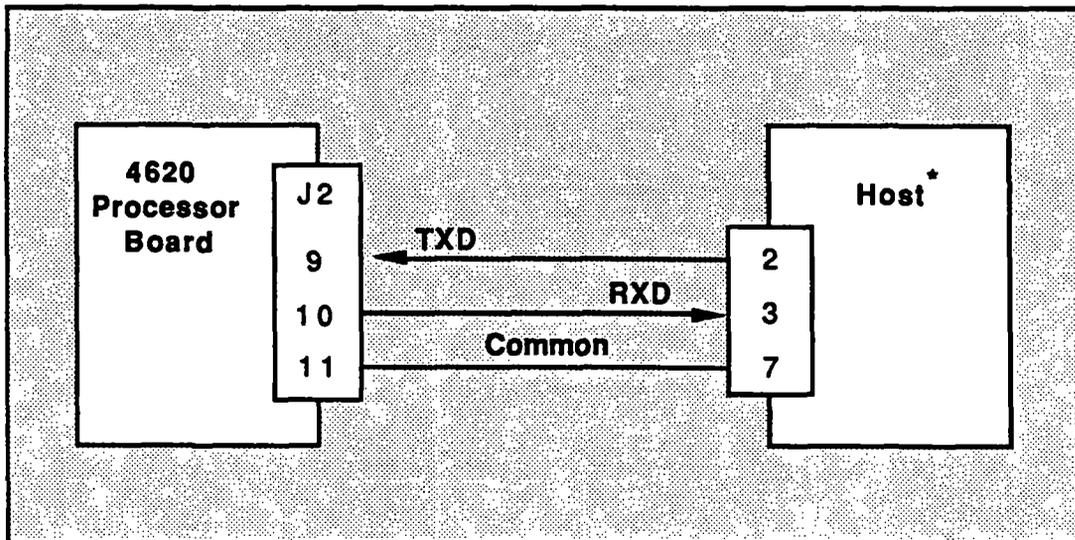
4.4.1 Serial Communications

Data communications between the host and the 4620 take place through connector J2 on the Processor board. Figure 4.4 shows a typical connection.

Data communications with the 4620 consists of individual bytes of data transmitted over an RS-232 serial port. The 4620 transmits data only in response to a command issued by the host processor. Data transfer is asynchronous; that is, there is no fixed timing requirement between command and response transmissions. Handshaking between the 4620 and the host computer is not required.

Note that Section 6, Communications Protocol, describes the general structure of the data packets, and Appendix A (Command List) describes each command and response in detail.

Data rate is 19.2 kbaud.



* Host shown as DTE if standard RS-232 pinouts are used.

Figure 4-4. Connections, RS-232 Interface to Host

4.4.2 Timing Considerations

This section describes the rate at which data is transferred to and from the 4620, and is included primarily to assist the user in defining timing requirements for software development.

Basic operating cycle: The 4620 timing is dependent on rotation of the filter wheel. Each rotation takes 10.5 milliseconds, during which time data is acquired for all gas channels, calculations are performed, and data is communicated to the host. Thus, the basic operating cycle of the 4620 is 10.5 ms.

Command timing: A single command consists of from 4 to 13 consecutive bytes, depending on which of the 20 available commands is issued by the host.

From a timing standpoint, the 4620 monitors the serial bus continuously for incoming data. Note that there is a one second restriction on the maximum time to transmit a command. At 19.2 Kbaud a single byte requires approximately 0.5 millisecond to transmit. Therefore the time required to transmit the longest command, 13 bytes, is significantly less than one second.

Response timing: A single response from the 4620 consists of from 5 to 17 consecutive bytes referred to as a data record. The amount of delay between the receipt of a command and the beginning of the response varies somewhat from command to command. Specific timing information for each command will be included in Appendix A of this manual.

In the case of continuous data transmission (command \$43), data records are transmitted continuously every 10.5 ms. For all other commands, the 4620 responds with a single data record.

For all 4620 responses, the time required to transmit the complete response is always less than 10.5 milliseconds. Note that Section 6, Communications Protocol, describes the general structure of the data packets. The figure below is an example of Continuous mode transmission, in response to the \$43 command (Transmit Channel Data, Continuous). As shown, a new data record is transmitted every 10.5 milliseconds.

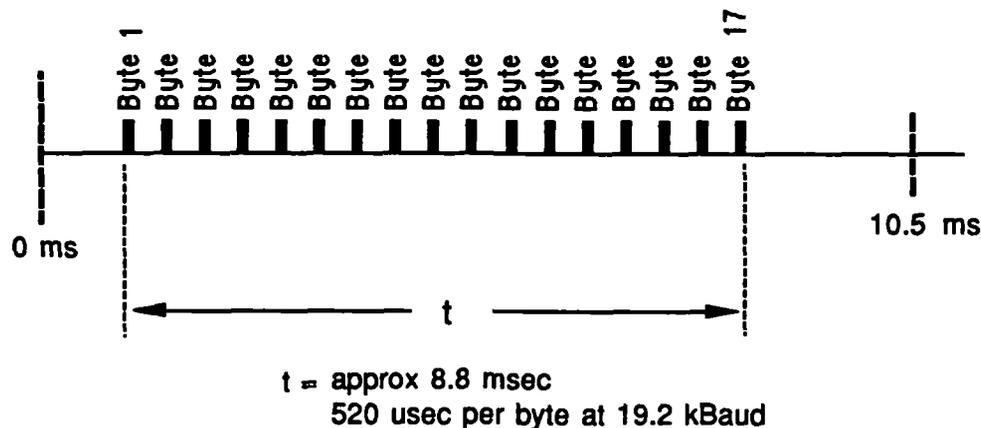


Figure 4-5 Timing Example, Continuous Mode

4.5 MOUNTING AND COOLING

4.5.1 PC Boards

The Model 4620 electronics assembly consists of two printed circuit boards, the Processor board and the SMR board. Although these boards are fastened together when shipped, they may be separated if this simplifies fitting them into the host system.

4.5.2 Optical head

The optical head is equipped with a number of 6-32 tapped mounting holes and may be mounted in any position. Ventilation may be provided in any manner as long as the cooling requirements in Section 2 of this manual are satisfied.

The head is connected to the electronics via a 34 conductor flat ribbon cable that attaches to connector P4 on the SMR board. If the 18 inch cable supplied is not sufficient, a cable length of up to 30 inches may be used. Note that if custom cables are made, it is necessary to match up pin 1 on the optical head with pin 1 at the electronics.

The location of the head should allow access to the removable sample cell without major disassembly.

4.6 PNEUMATIC REQUIREMENTS

4.6.1 Overview

The 4620 Block Diagram (see foldout drawing) shows the necessary pneumatic connections and the gas flow path through the system. Note that the pneumatic components shown are available from Andros as an integrated assembly, Model 1401, described in Section 8 of this manual.

Basic requirements for any pneumatic configuration are as follows:

Pump: The sampling pump should provide a smooth and constant gas flow. Standard flow rates are 65 and 200 milliliters per minute. Two hundred ml/min is recommended to ensure the specified response time.

Filter: The gas in the patient airway adapter should be filtered to remove water droplets and other contaminants.

Solenoid valve: A solenoid valve is required to allow either sample gas from the patient or room air to be selected. It is desirable that the air sample supplied to the 4620 during a Zero routine be obtained from an area as close to the optical head as possible. Note that air samples that are close in proximity to the exhaled breath from operators or other personnel may vary in CO₂ content.

The 4620 provides a means of switching the solenoid valve during the Zero routine. As described in Section 4.6.2, a logic level signal from the Processor board performs this function.

Connections to sample cell: See section 4.6.3.

Oxygen sensor: See Section 4.7.

Exhaust: The exhaust gas from the system should either be scavenged or returned to the patient circuit.

4.6.2 Control Lines

Header P2 on the 4620 Processor Board supplies TTL-level control signals to the solenoid valves and the pump. These lines are normally connected to driver circuits in the pneumatics assembly that control these devices.

Pump lines: There are three pump control lines. These lines are switched by issuing a \$60 (Pump Control) command and including the correct instruction in the PS byte. See Command \$60 in Appendix A for the command format. The condition of these lines is also reported in the Status word (Status codes 30 and 31).

Solenoid lines: There are two solenoid control lines. These lines are switched by issuing a \$E1 (Solenoid Control) command and including the correct instruction in the AS byte.

Note that only one solenoid (Solenoid 1) is required for operation by the 4620. This solenoid switches from sample gas to zero gas during the zero procedure. The other logic line (Solenoid 2) is uncommitted, and may be controlled by the host using the \$E1 command. The condition of these lines is also reported in the Status word (Status codes 44 and 45).

Occluded: This line may be connected to a customer-supplied pressure sensor in the sample line. When an occlusion is indicated, the condition is reported in the Status word (Status code 06) and causes the Check Status bits to be set. These bits are cleared when the Occlusion line is restored to a "0".

The control lines from the 4620 to the pneumatics assembly are:

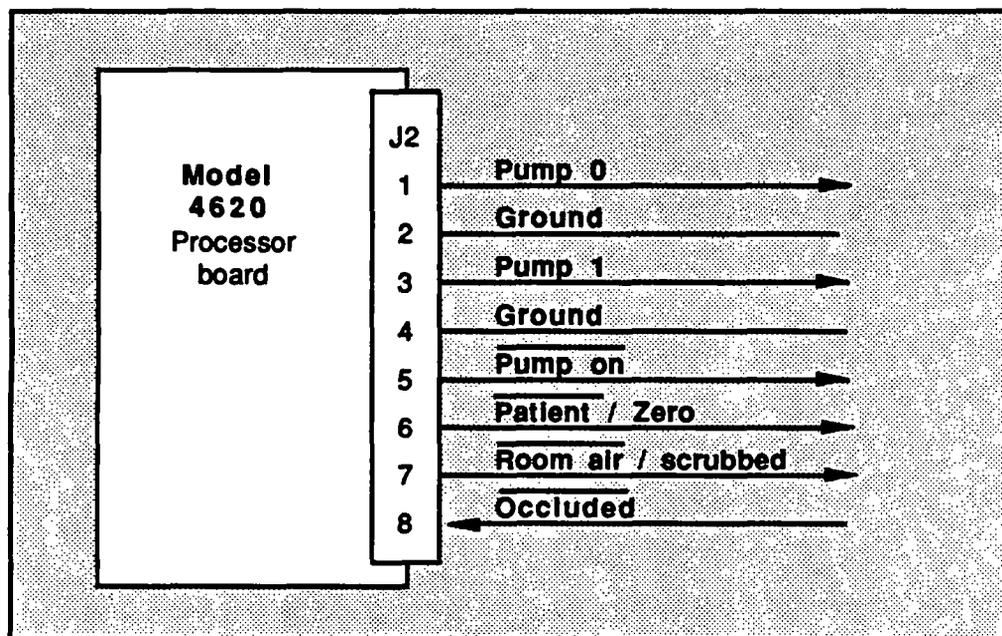


Figure 4-6. Connections to Pneumatics Assembly

4.6.3 Disposable Sample Cell

The sample cell is designed to be used from patient to patient unless it becomes contaminated. Contamination frequently includes liquids, mucous or bacterial matter. The inside of the cell is not designed to be cleaned or sterilized as any residues left inside the cell can invalidate the gas measurements. **Once a sample cell is contaminated, even with a single droplet of water, it must be replaced. Failure to do so may result in inaccurate or misleading readings.**

As described in Section 5, contamination usually causes Status Code 31 (Reference Level Shift) to be set in the Status word. This condition also causes the Check Status flags to be set.

Sample Cell Removal

1. Grasp the sample cell by the handle and pull gently.
2. The plastic tubing attached to the sample cell is not easily removed from the cell. Normally, both lengths of tubing are removed with the cell.

Sample Cell Installation

1. Connect new sections of tubing to the inlet and outlet ports of the replacement cell. The inlet and outlet ports are interchangeable.
2. Insert the sample cell into the recess in the optical head with the handle toward the outside edge of the head. The sample cell has a bevel along one edge to prevent mis-insertion.
3. Push the sample cell in until the detent is felt.

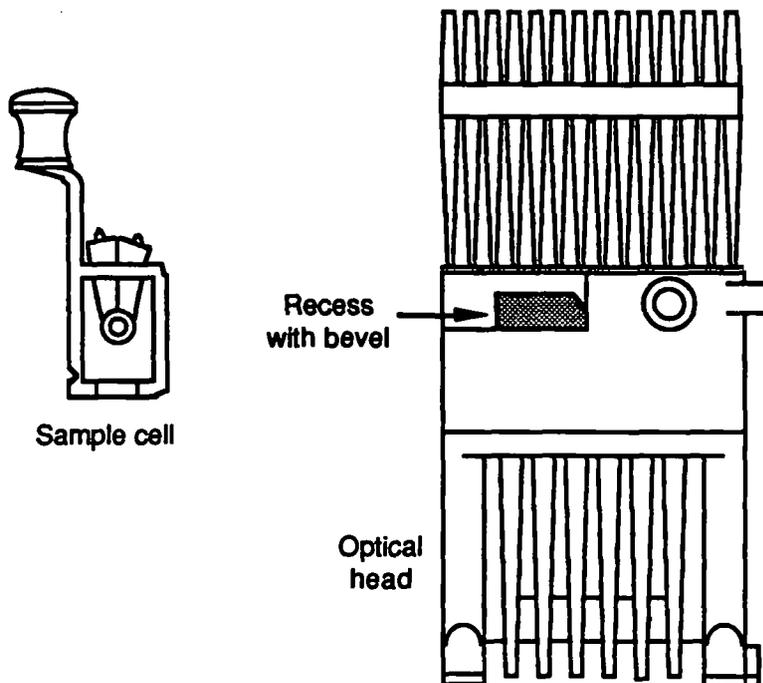


Figure 4-7.
Sample Cell Installation

4.7 OXYGEN SENSOR

The 4620 has provision for connecting an analog type Oxygen sensor to the analyzer. Whether or not to use an analog sensor depends on the configuration of the host system.

Oxygen concentration information is required by the 4620 to correct span error in the CO₂ channel when both gases are present in the sample cell. There are two ways to provide Oxygen concentration to the 4620:

- An analog type sensor may be placed in the sample line and connected to the 4620 sensor input terminals. The 4620 performs an analog to digital conversion and computes concentration. This is the default mode for the 4620. If an analog sensor is used, its output characteristics must conform to the requirements described below.
- Alternatively, Oxygen concentration in the sample line may be measured by the user and supplied digitally to the 4620, using the \$11 command. If O₂ concentration is sent to the 4620 with this command, the analyzer ignores the analog input. See the \$11 command description in Appendix A for further information on this approach.

In either case, the 4620 uses the Oxygen data to compensate the CO₂ channel. If Oxygen data is not supplied, there will be significant errors in the accuracy of the CO₂ measurement.

In addition, the O₂ concentration data is transmitted to the user during normal gas channel transmission.

Sensor characteristics: The 4620 signal conditioning circuit is designed to accommodate an Oxygen sensor with a full scale (100%) output in the range of 20 to 120 mV. Sensor output must be a linear function of oxygen concentration. It is also assumed that a 0% concentration will result in zero volts output from the sensor.

Calibration: Note that fuel-cell type sensors require frequent calibration. In addition, the O₂ sensor must be placed at atmospheric pressure for greatest accuracy. Section 5.4.6 describes Oxygen sensor calibration.

Connections: Connections for the Oxygen sensor are as shown:

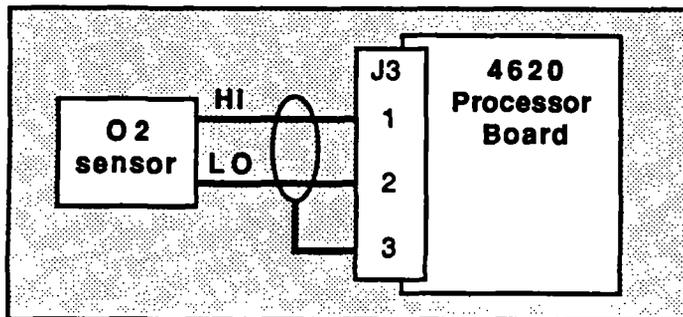


Figure 4-8.
Connections, Oxygen Sensor

SECTION 5 OPERATION

5.1 OVERVIEW

This section describes the major routines required to operate the Model 4620, from powering up the unit to acquiring data. Flow charts and step by step procedures are given to assist the host programmer in software development. These procedures give an overview of the operation of the analyzer.

This section is divided into five main areas:

- Normal operation
- Zero routine
- Calibration
- Status
- Error handling

This section assumes that the interface requirements described in Section 4 are satisfied. Note that the procedures given in this section are for reference only, and that the host system requirements will determine how the 4620 is programmed in a given application.

5.2 NORMAL OPERATION

Once the 4620 is installed, the unit is completely controlled through the data communications port on the CPU. The system is designed to operate via a "host" computer or microprocessor system supplied by the user. The host is responsible for issuing commands, receiving measured data, requesting status from the 4620 and initiating the Zero and Calibration routines. Note that the 4620 analyzer will perform no operations and transmit no data without commands from the host.

There are no requirements for initialization of the 4620 prior to use. Assuming that the 4620 is properly integrated with the host system, the unit is designed to perform gas analysis "out of the box".

5.2.1 Initial Power On

This section describes the recommended start up sequence. This procedure also appears in a flow chart (see Figure 5-1).

It is not necessary for the host to perform a reset when power is applied to the 4620 since a power on reset is performed automatically. (Note that the 4620 has provision for both hardware and software resets. Additional information on the reset function may be found in Section 4.3.)

Within a few seconds after power up, communication may be established. A Status request (\$01) may be issued periodically and the status response examined. During the warm up sequence, the system status bits will clear in the following sequence:

- The System Fault - Self Test bit (Status code 00) goes low after a few seconds, indicating that the analyzer has passed the Self-test sequence. Communication with the 4620 can be established after this bit goes low.
- The Timing Servo bit (Status code 01) goes low after approximately 20 seconds, indicating that the motor speed is correct.
- After one minute the Warm up Timer Counting bit (Status code 04) goes low. This bit reports that one minute has elapsed since power up. In addition the Zero Required bit (Status code 05) is set, as well as the Initial Zero Required bit (Status code 33).

At this point a Zero routine must be performed to obtain usable data from the analyzer.

Recommended Zero Interval: In order to meet accuracy specifications while the analyzer stabilizes, the following schedule is recommended. The user is advised that this schedule is preliminary.

<u>Time after power up</u>	<u>Action</u>
1 minute	Perform initial Zero
2 minutes	Perform Zero
5 minutes	Perform Zero
15 minutes	Perform Zero
after 15 minutes	Zero every 30 minutes

This schedule assumes that no significant temperature transients occur. If the host initiates the required Zero routines, data may be considered valid during warm up period.

Note that the above start up procedure should also be followed any time a Full Reset is performed on the analyzer. This is because the servos are reset and require time to re-stabilize (see Section 4.3).

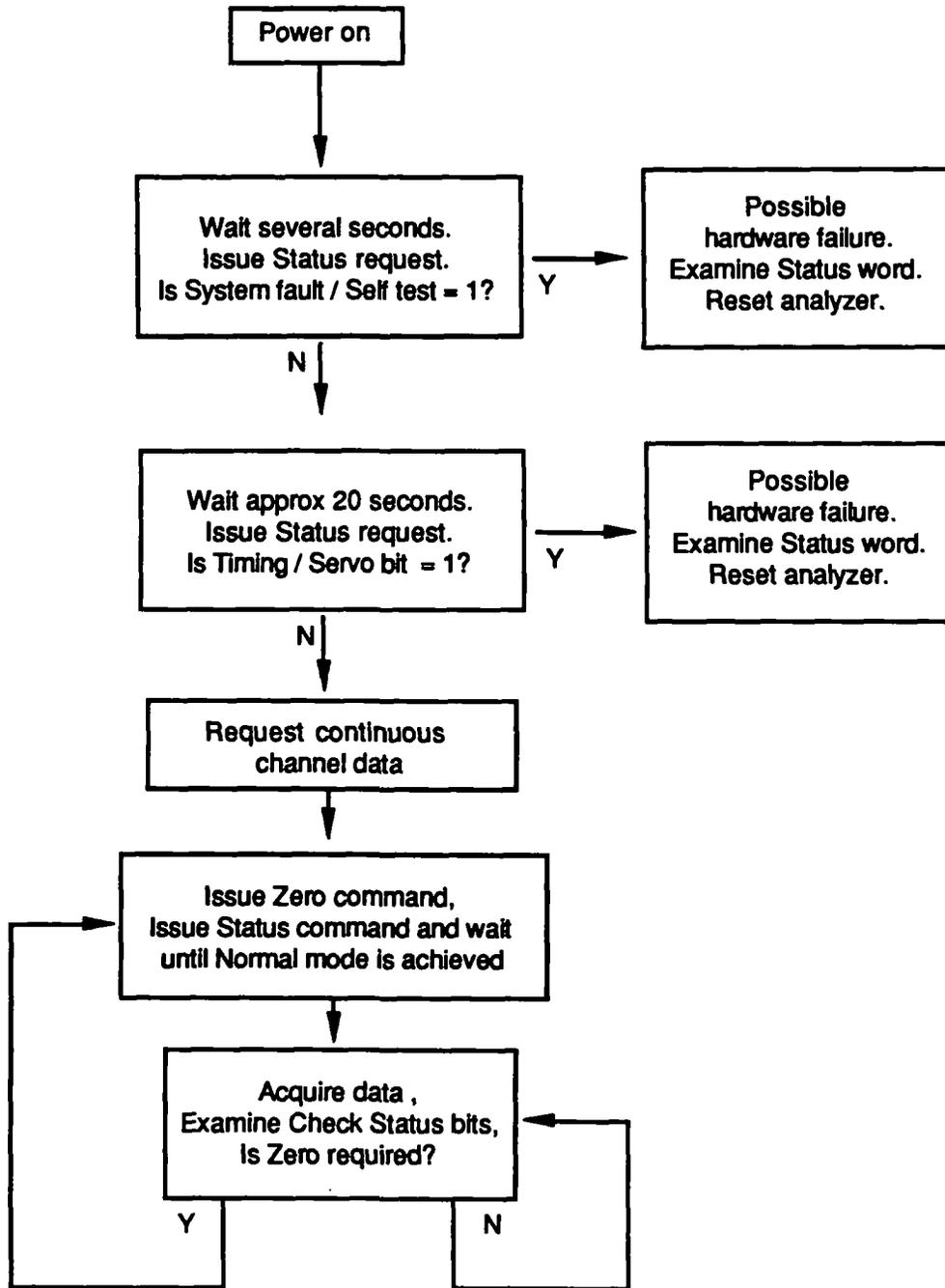


Figure 5-1. Operation flow chart

5.2.2 Receiving Channel Data

The 4620 will not transmit any data without a specific command from the host. Data is transmitted according to the format described in Section 4.4 (Communication and Timing) and Section 6 (Communication Protocol).

Channel data can be requested either one record at a time (\$40) or continuously (\$43). When continuous transmission is selected, the data packets are delivered in real time at 10.5 millisecond intervals. To avoid loss of data the host computer must be configured to accept and process the 4620 output at this rate.

In addition, either compensated or uncompensated data may be selected (\$D2 or \$D3). In normal operation, compensated data is selected, which returns data in units of gas concentration for each channel. Uncompensated mode is used primarily for diagnostic purposes, and returns IR pulse absorption data.

Check Status condition: To ensure the integrity of gas concentration data, it is the responsibility of the host to monitor the status of the analyzer. If a problem exists that could affect data accuracy, the analyzer will report a Check Status condition.

The Check Status bits are found in two locations:

- Within the Channel Monitor byte. This byte is transmitted along with every set of channel data in response to a \$40 or a \$43 command. It contains a Check Status bit for each channel transmitted.
- Within the Dynamic Status byte. This byte is contained in every response issued by the analyzer and is completely described in Section 6.4.4.

Dynamic Status byte: The Dynamic Status byte should be inspected if the Check Status bit is set. The contents of the Dynamic Status byte are normally sufficient to determine the cause of the problem. If additional information on analyzer status is needed, the Status Word should be requested (command \$01).

The most frequent reason for a Check Status condition is the need to perform a Zero routine. However other problems, such as data processing errors and improper operating modes, can also set the Check Status bits.

Note also that each data record is terminated with a Checksum byte. It is strongly recommended that this byte be examined after the receipt of each record.

Please refer to the following sections of this manual for further information:

Channel Monitor byte	Appendix A (Command list), \$40 command
Dynamic Status byte	Section 6 4.4
Status word	Section 5.5
	Appendix B (Status Response Format)
Error Handling	Section 5.6
Checksum	Section 6.4

5.3 THE ZERO ROUTINE

5.3.1 Description

The Zero routine is initiated by the host and resets the baseline value for the CO₂ and N₂O gas channels to zero. During this process, the 4620 sends logic signals to the pneumatic components to introduce room air into the sample cell. The N₂O and CO₂ channels are set to zero, and the pneumatics assembly is then reset to normal mode, in which sample breath from the patient is analyzed. The concentration of CO₂ and N₂O in room air is sufficiently low to be used for Zero gas for these channels.

Zero Interval: The Zero interval is the maximum time allowed between Zero routines to meet 4620 accuracy specifications. For a warmed up 4620 operating in a stable environment, the Zero interval is 30 minutes. This interval is not timed or reported by the 4620.

Parameters monitored: The 4620 monitors four general conditions to determine if a Zero is required. They are:

- Temperature drift
- Changes in IR transmission in the optical head
- Unsuccessful Zero routine
- Warmup timeout (initial Zero only)

If any of the above conditions occur, it is reported in three locations:

- The Channel Monitor byte (transmitted with every set of channel data)
- The Dynamic Status byte (transmitted with every 4620 response)
- The Zero Status bits (located in the Status Word)

As described previously, the host should continuously monitor the Channel Monitor and Dynamic Status bytes to determine if a Check Status condition is in effect. If so, the Dynamic Status byte should be inspected to determine if a Zero is needed.

The Zero routine: The Zero routine takes about XX seconds, in addition to the requested purge time. During this time the 4620 electronics are adjusted by the microprocessor to give zero output for the three gas channels.

Following a successful Zero routine, the following bits are reset:

- In the Dynamic Status byte:
 - The Check Status bit (Status code 07)
 - The Zero Required bit (Status code 05)
- In gas channel data transmission:
 - The Check Data bit

5.3.2 Purge Time

As outlined in section 4.6.3 (Zero Considerations), enough purge time must be allowed to enable the concentration of CO₂ in the sample cell to drop to within approximately 100 PPM after room air is switched into the sample stream. This time is specified by the purge time byte in the Zero command (see Appendix A, Command List). When commanded to perform a Zero, the 4620 will flow room air for the requested purge time before adjusting the 4620 output levels.

Purge time test procedure: The designer must verify that an adequate purge time is specified. The required purge time depends on the specific design of the pneumatic system. The following test procedure is provided to assist the user in evaluating the purge time of the pneumatics circuit.

1. Allow the 4620 to warm up for a minimum of 15 minutes.
2. Set up the pneumatics system to switch between the following test gases:
5% CO₂/balance N₂
Room air
3. Set the 4620 to display continuous uncompensated data (commands \$D3 and \$43). Uncompensated data gives higher resolution at low concentrations of CO₂. A demonstration program is available from Andros for capturing data and generating printed results.
4. Issue a \$E1 command to switch Solenoid 1 to the Room Air position. While flowing room air allow readings to stabilize. Average and record the uncompensated CO₂ output in counts. This value is considered "zero" for the test.
5. Issue a \$E1 command and switch the flow to CO₂ test gas for 10 seconds.
6. Return the flow to scrubbed room air and note the time it takes for the CO₂ channel to return to within several counts of the "zero" value noted in Step 4. This time interval is the approximate minimum purge time for the system.
7. Continue to flow room air for at least two minutes, and ensure that system drift (comparing the output with the step 4 value) is several counts or less. The test should be repeated several times to allow for drift and noise. Always allow the system to flush with scrubbed air for a minimum of two minutes between tests.

When the customer performs a gas calibration, the 4620 characterization information in NVRAM remains unchanged. Instead, the span scalar associated with each channel is adjusted. The span scalar assumes whatever value is necessary to allow the reported concentration to match the calibration gas value entered by the customer. Note, however, that if any span scalar is outside of the range 0.75 to 1.25, the 4620 will issue an error message.

The span scalars are also stored in NVRAM, allowing customer calibration settings to be retained in case of loss of power. The benefit of using span scalars is that the look-up tables and other analyzer characteristics remain intact, whether or not a Span routine is performed. The 4620 can easily be restored to factory calibration by resetting the span scalars to 1.0 using the Reset Span command.

The user may confirm calibration settings at any time by comparing the 4620 output with known cal gas concentrations. One or more gas channels may be adjusted.

The Span routine is the most complicated procedure the user will perform with the 4620. A flow chart showing the suggested span procedure is given in this section.

5.4.2 Calibration requirements

Selection of calibration gases: For greatest accuracy, the calibration gases should be approximately equal in concentration to the gases being analyzed. The following table shows the allowable range of cal gas concentrations and suggests a recommended "cocktail" blend. Most users will find this mixture gives good results.

Calibration gas concentrations

	<u>Allowable</u>	<u>Recommended</u>
CO ₂ :	20-85 Torr 3.3-11.2 %	38 Torr 5 %
N ₂ O:	20-100 %	60 %
O ₂ :	15-100 %	35 %

If the 4620 receives a concentration value outside of the allowable range it will respond with an error message:

5.4.3 Span Procedure

1. **Inspect the sample cell.** Remove the sample cell and inspect it visually for contamination from fluids or other matter.
2. **Warm up the analyzer.** For maximum accuracy the 4620 must be warmed up for at least 30 minutes. Stability can be determined by issuing a \$01 Status command and examining the Zero interval bits. The 4620 should be in 5 minute mode (this occurs approximately 30 minutes after power up).
3. **Select cal gases.** Any number of channels from 1 to 3 may be calibrated during a Span routine. The calibration gas may be a "cocktail" blend or a series of binary gas mixtures.

The gas mixture in the tank must be uniform. Generally, calibration gas mixtures should be stored at room temperature (23C or higher) and subjected to some handling before use. For more information on this subject, consult the calibration gas manufacturer.

4. **Purge the pneumatics circuit.** Turn on the pump and flow a Zero gas such as room air or Nitrogen through the system. For greatest accuracy of the CO2 channel, Nitrogen is preferred. At 200 milliliters per minute, a 5 minute purge time is sufficient.
5. **Zero the analyzer.** Issue a \$20 command. After completion of the Zero routine, examine the status word to be sure all error flags are clear. Issue the \$43 command (Transmit Channel Data, Continuous) and inspect the channel data to ensure that all channels were properly zeroed. Continuous data transmission may remain in effect for the rest of the Span routine. However, the host computer should be prohibited from sending any additional Zero commands during the remainder of the Span procedure, which may exceed 5 minutes.

- 6. Verify pressure and O2 channels.** If these channels are not calibrated, the accuracy of the other gas channels will be affected. Refer to the following sections for calibration of the O2 and pressure channels.

The O2 channel significantly affects CO2 channel accuracy. When fuel-cell type O2 sensors are used, it is common practice calibrate the O2 channel daily using room air as a calibration gas. If the O2 channel is known to be accurate, the user may proceed to the next step.

If Oxygen calibration is required, the O2 channel should be calibrated first in a separate routine. The calibration gas may be room air, a binary gas mixture, or a "cocktail" blend containing balance Oxygen in a known concentration. The Span procedure should be followed first for Oxygen and then repeated for the remaining gases.

- 7. Check existing 4620 calibration.** Flow calibration gas until readings are stable (about 30 seconds to 1 minute). Examine the reported concentration by issuing the \$43 command (Transmit Channel Data, Continuous). Note that a low flow rate, such as 50 to 100 milliliters per minute, can be used to conserve calibration gas. If the gas concentrations are within 4620 accuracy specifications, the calibration process is complete. No additional steps are required.

When examining channel data, note that a large discrepancy between the 4620 output and the calibration gas concentration may indicate that the cal gas is incorrect or it is not being delivered properly.

- 8. Issue Reset Span.** Before proceeding with the customer calibration, the \$22 command should be issued to restore the 4620 to its factory settings. This has two purposes: First, it may restore the analyzer to specified accuracy. Second, it can be useful for locating certain errors that may affect analyzer calibration. After resetting span, check the reported concentration. If the channel data is within specifications, the calibration process is complete. If it is not within specifications, proceed with the following system checks.
- 9. Check for dilution.** If there is dilution of the calibration gas and the 4620 is in the reset span condition, all channel data will read low by the same proportion. The customer should verify that there are no leaks in the pneumatics assembly (sample cell, fittings or plumbing) that may cause dilution.

10. **Verify correct CO2 Zero.** Proper operation of the pneumatics circuit should be verified. As described in Section 5.3, room air must be delivered to the sample cell during the Zero routine.

If cal gas dilution and Zero problems are not corrected, a Span Fail condition may be reported later in the procedure (see step 13).

11. **Flow cal gas.** Introduce the cal gas mixture into the the sample cell. Examine the gas data and wait for the reported concentration to stabilize. At 200 milliliters per minute, a period of 30 seconds to 1 minute is normally sufficient.
12. **Issue Span command.** Assuming the system is operating properly, the Span command \$10 should be issued. For each channel to be calibrated, the host must send: 1) a tag value mask (TVM) byte and 2) the cal gas values.
13. **Issue status command.** After sending the Span command, a Status command should be issued. Verify that the Span in Progress bit is set and that Span Fail has not occurred. If "Span Fail" appears, the span scalars exceed the acceptable limits (0.75 to 1.25). However the 4620 will complete the span operation with the new values.
14. **Verify Span** When the status word reports "Normal" mode, check the reported gas concentration against the cal gas tag values. If the accuracy is within specification, the calibration sequence is complete.

If it is not, refer to section 5.4.4 (Span Failure) and repeat the Span procedure. If the unit cannot be spanned after two attempts, service may be required.

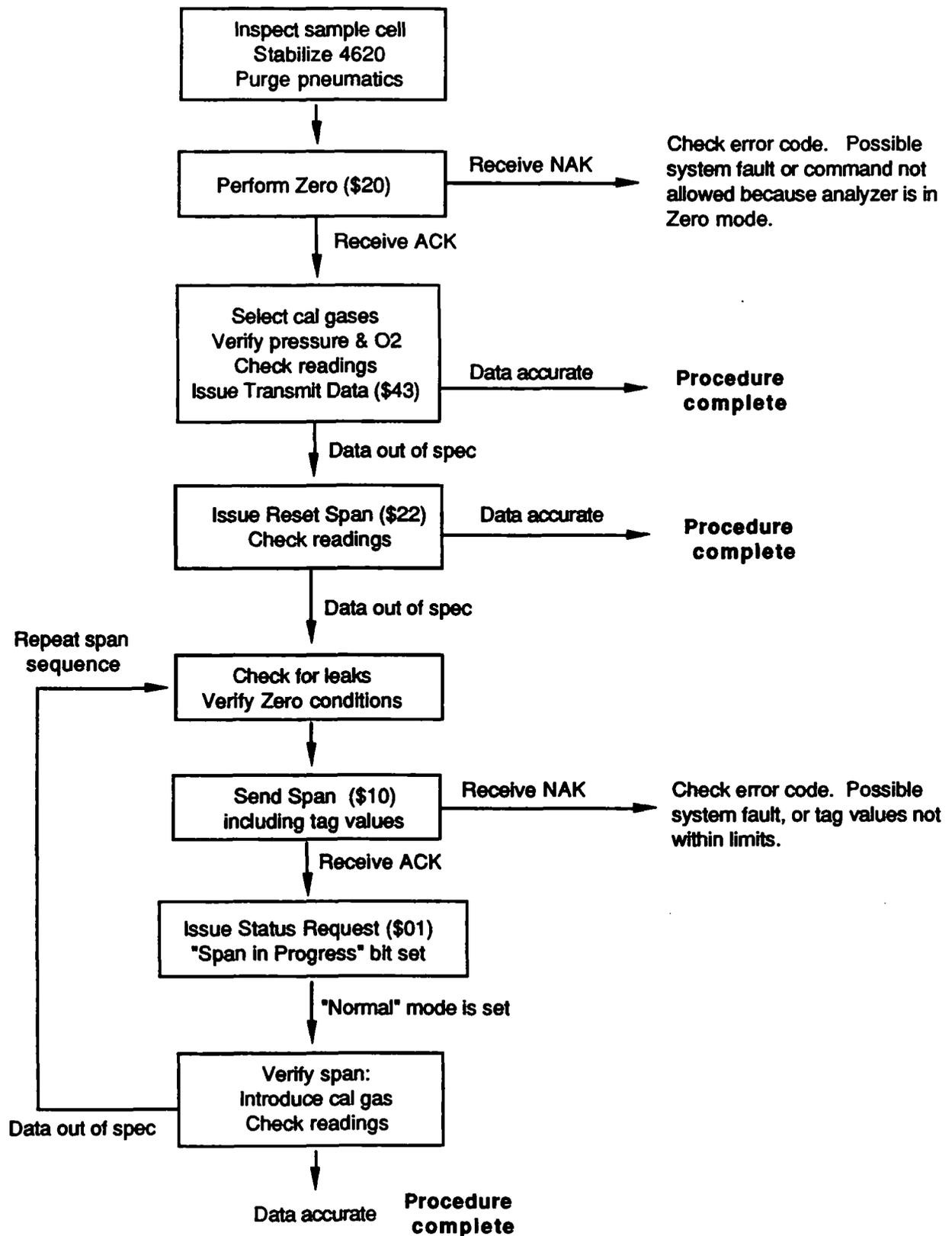


Figure 5-3. Calibration Flow Chart

5.4.4 Span Failure

A Span failure occurs if the 4620 does not meet accuracy specifications after performing the Span procedure. A number of problems can cause such a failure. Some of these problems, but not all, will cause the 4620 to report a Span Fail condition in the Status word. The only way to confirm a successful Span procedure is to examine the 4620 output using test gases of known accuracy.

The span characteristics of the 4620 are very stable. The span scalars resulting from a customer span are expected to vary no more than 5 to 10% from factory settings over the lifetime of the analyzer.

Span Fail bit: If any span scalar changes more than 25% from factory settings, the 4620 reports a Span Fail condition. The Check Data flag for that channel is also set, allowing the user to identify the failed channels. These flags may be reset with subsequent Spans if the new span values are within the required range. The flags may also be reset by resetting the span gains to factory default values using the Reset Span (\$22) command.

Reasons for span failure: The most likely reasons for a faulty span routine are:

- Analyzer not properly Zeroed.
- Calibration gas concentrations not entered correctly during span procedure.
- Pneumatic system leaks causing dilution of calibration gas.
- Improper delivery of calibration gas, caused by insufficient flow rate to the sample cell, pump off, etc.
- Gas not allowed to stabilize prior to issuing Span command.
- Gas mixture settled or not properly blended in tank.
- Introduction of the wrong calibration gas

Hardware failure or excessive span drift due to deterioration of the optical assembly will also cause span failure. However if these faults are sufficiently large to cause Span Fail to be set, then additional error flags will be set in the Status word. These types of failures must be corrected at the factory or at a service depot.

5.4.5 Pressure Calibration

The pressure transducer is located on the processor board and, when properly connected, is used to measure sample cell pressure. The pressure information is used to correct the CO₂ and N₂O concentration data on a continuous basis. Note that the 4620 does not perform pressure correction of the O₂ channel.

The transducer generates an analog signal that is processed by circuitry on the Processor PC board. This circuitry contains two potentiometers: one for setting zero and one for span.

Faulty calibration of the pressure circuit can affect the accuracy of the CO₂ and N₂O channels, and may be indicated by a System Fault - Self Test error in the Status word. The calibration procedure requires a pump and an accurate pressure indicator. It may be performed at an Andros service depot or by the user. Customers who wish to perform this procedure should consult the Andros Applications Engineering department for further information.

55-56 mV at ~~100~~ 95% O₂

R14
~
600-800 torr

5.4.6 Oxygen Channel

If the information is supplied to the 4620 in digital form, no calibration is required. If an Oxygen sensor is used, regular calibration must be performed, as described below:

Oxygen sensor calibration: The accuracy of the CO₂ channel data depends on the calibration of the Oxygen sensor. For fuel-cell type sensors it is common practice to perform the calibration daily. The procedure has two steps, consisting of a span adjustment and a linearity check. The procedure is as follows:

- The Span procedure is performed for Oxygen using the \$10 command, as described in section 5.4.3. Room air concentration (21%) is typically used as a calibration point. Note that the cal gas tag value must be in the range of 1.5 to 100%.
- In order to check linearity, Oxygen is then introduced into the sampling system at a second concentration, such as 100%. With the 4620 transmitting continuous data, the O₂ concentration is read. If this reading is not within a few percent of the actual value, the transducer should be considered non-linear or non-operative.

This two-point calibration is particularly important when using fuel cell type oxygen sensors, since non-linear response at full scale concentration is a preliminary indication of cell exhaustion.

Note that the Oxygen sensor circuit contains an additional potentiometer, R23, for setting the zero point. This adjustment is rarely required.

Pressure correction: The 4620 performs no pressure correction of the O₂ channel.

5.5 STATUS

5.5.1 The Dynamic Status Byte

The Dynamic Status byte (DSB) provides the user with general status information without having to issue a Status request. This feature is useful when receiving continuous channel data. The following are some specific conditions for which the host program would inspect the DSB.

- After power-on, to ensure that the analyzer successfully completed the Self-Test routine.
- During warm-up, to check motor speed and servo stability.
- While receiving continuous channel data, to confirm data validity.
- Following the execution of a Zero or a Span command. The user may "chase" these commands with a Status request to determine when the command has completed executing, and to confirm the condition of the 4620.

A Dynamic Status byte is contained in every 4620 response. The contents and location of this byte are described in Section 6.

5.5.2 The Status Word

The Status word is generated in response to a \$01 command and provides greater detail on the condition of the analyzer. It reports error conditions and the state of the various logical switches. Appendix B of this manual describes the contents of the Status word.

The Status record may be requested at any time. It is frequently requested if a Check Status flag is detected during data transmission, to identify an error condition.

5.5.3 Status Codes

Each bit in the Status word has a number associated with it that uniquely identifies the position of the bit in the Status word. These numbers are referred to as Status Codes. Each of the Status Codes is described in detail in Appendix B.

Note that Status Codes 00 through 07 refer to the contents of the Dynamic Status byte.

5.5.4. Information Flags

The contents of the Status Field have been grouped into four categories to assist the host system programmer. These categories are:

- Information flags
- Error flags - Correctable
- Error flags - Fatal
- Diagnostic flags

Note that some status and error bits fall into more than one category. In the following lists, the Status Code number appears next to each message.

The Information flags indicate whether the 4620 is in one logical state or another; for example whether the pump is on or off. These bits are descriptive only, and do not directly reflect the accuracy of the gas concentration data. They do not set any Check Status flags in the status word.

<u>Status code</u>	<u>Message</u>
02	Mode (normal, zero, span in progress)
34	Output filtering
40	Continuous readings on/off
42	O2 / reference output
43	CO2 in percent / Torr
44	Solenoid 1 on
45	Solenoid 2 on
46	Pump state

5.5.5. Error flags - Correctable

These flags indicate that the accuracy of the data transmitted by the 4620 cannot be guaranteed. They are normally reset by completing the corrective action listed in Appendix B.

<u>Status code</u>	<u>Message</u>
01	Timing - servo Fault
02	Mode (filter wheel timing fault)
04	Warmup timer counting
05	Zero required
06	Occluded
20	Compensation on / off
24	Span fail
25	Zero fail
26	A to D fail
27	Pressure range (if occlusion indicated)
30	Temperature drift
31	Reference level shift
32	Zero failed
33	Initial Zero required
51	AGC error
55	Comp pressure invalid
56	Comp CO2 invalid
61	Comp N2O invalid
62	Underrange
63	Overrange

5.5.6. Error flags - Fatal

These bits indicate hardware or other malfunction. They cannot be corrected by issuing any command sequence. If the problem cannot be corrected by resetting the 4620, adjustment or repair of the analyzer or the related subsystem is indicated.

00	System Fault - Self Test
27	Pressure range (if electronic failure indicated)
11	Power fail
12	NOVRAM fail
13	RAM fail
14	ROM fail
52	Channel data processing error

5.5.7. Diagnostic flags

These bits are not commonly used by the customer because they are not implemented or they are for diagnostics only. They are designated Not Used in the Status Field description appearing in Section 6. Consult Andros for further information.

5.6. ERROR HANDLING

5.6.1. Types of Errors

Error flags are set when the 4620 software tests a condition and the result is not satisfactory. The following table illustrates the types of 4620 error responses:

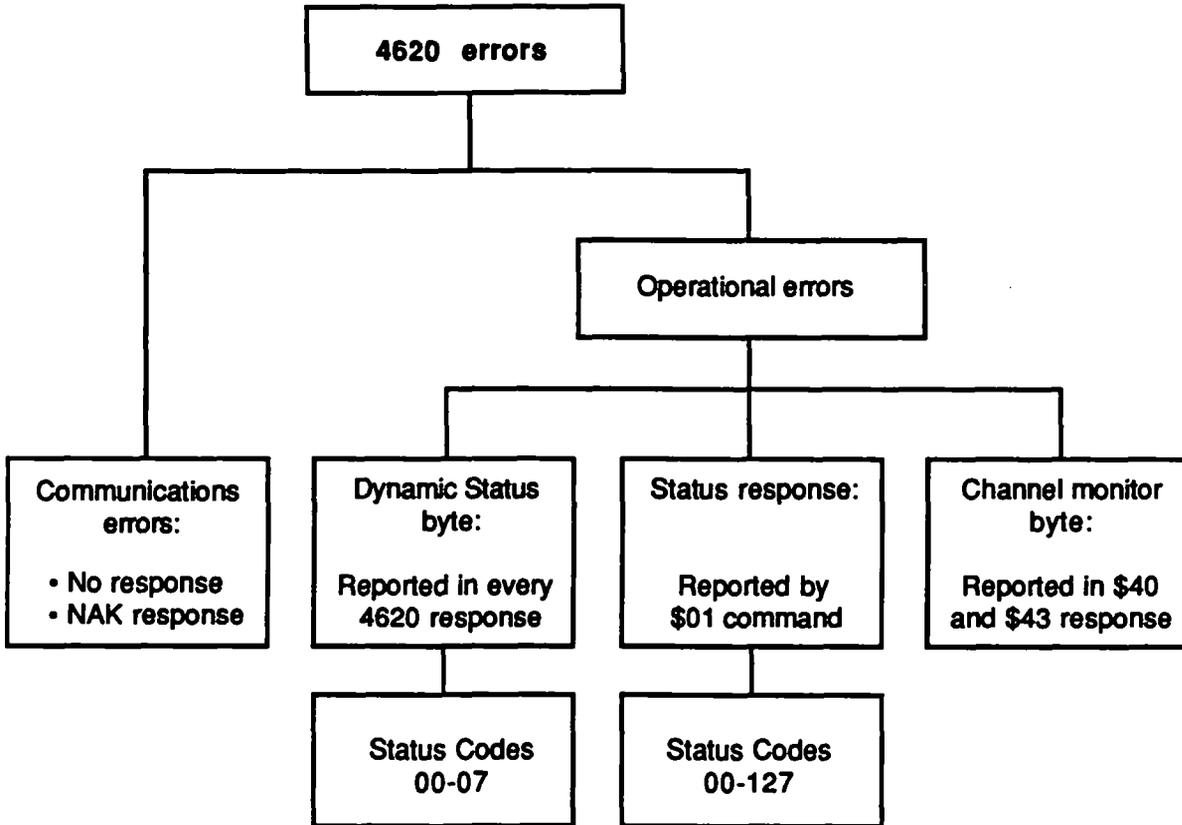


Figure 5-3. Error Tree

Communications errors are reported by either a no response condition or a NAK response, as described in Section 6.4 (Response Structure). Operational errors are reported in either the Status word or in the Dynamic Status byte.

5.6.2 How Errors are Reported

The following table summarizes all of the operational errors reported by the 4620 and indicates which of these errors also set the Check Status bits. The table includes both fatal and correctable errors.

The Status Code numbers alongside the error messages uniquely identify the position of the error in the Status word. The errors and Status Codes are more completely described in Appendix B.

Certain errors appear more than once in the Status word and therefore have more than one Status code. These errors are indicated by a "+" symbol in the table.

Some errors are also reported in the Channel Invalid bits located in the Channel descriptors (see Appendix B). The Channel Invalid bits are assigned Status Codes 64, 84, 104, 124 and 144, depending on the channel in which they appear.

Status Code	Meaning	Sets System Fault bit (Status Code 00)	Sets Check Status bit (Status Code 07)	Sets Zero Required bit (Status Code 05)	Channel Monitor bits	
					One or more	Sets all
	(Dynamic Status)					
00	System Fault		•			• •
01	Timing Servo Fault					• •
02	Filter wheel timing fault					
04	Warmup timer counting		•			•
05	Zero Required		•			•
06	Occluded		•			•
08	Check status					
	(Self Test)					
10	Signal Check	•	•			• •
11	Power Fail	•	•			• •
12	NVRAM Fail	•	•			• •
13	RAM Fail	•	•			• •
14	ROM Fail	•	•			• •
15	Processor Fault	•	•			• •
	(Real Time Check)					
20	Compensation		•			•
24	Span Fail		•		•	
25	Zero Fail		•		•	
26	A/D Limit Exceeded		•		•	
27	Pressure Range Exceeded		•		•	
	(Zero Request)					
30	Zero Req. - Temperature		•	•		•
31	Zero Req. - Reference		•	•		•
32	Zero Req. - Zero Failed		•	•		•
33	Zero Req. - W.U. Timeout		•	•		•
34	Output Filtering On/Off					
	(Channel Descriptors)					
51+	Channel AGC Error		•		•	
52+	Channel DP Error		•		•	
53+	Channel A/D Error		•		•	
55+	Channel Pressure Invalid		•		•	
56+	Channel Comp. O2 Invalid		•		•	
61+	Channel Comp. N2O Invalid		•		•	
62+	Channel Underrange		•		•	
63+	Channel Overrange		•		•	

Table 5-1. How Errors are Reported

5.6.2. Error handling routine

This section describes how to process errors received while receiving channel data from the 4620.

As described in section 5.2.3, the Check Status bits contained in the 4620 data records should be continuously monitored during data transmission to ensure data integrity and accuracy. Refer to command response \$40 and \$43 in Appendix A (Command Listing) for location of the Check Status bits. If Check Status is asserted on any channel, the Status word must be examined to determine the source of the problem.

The following flow chart shows a general error handling routine:

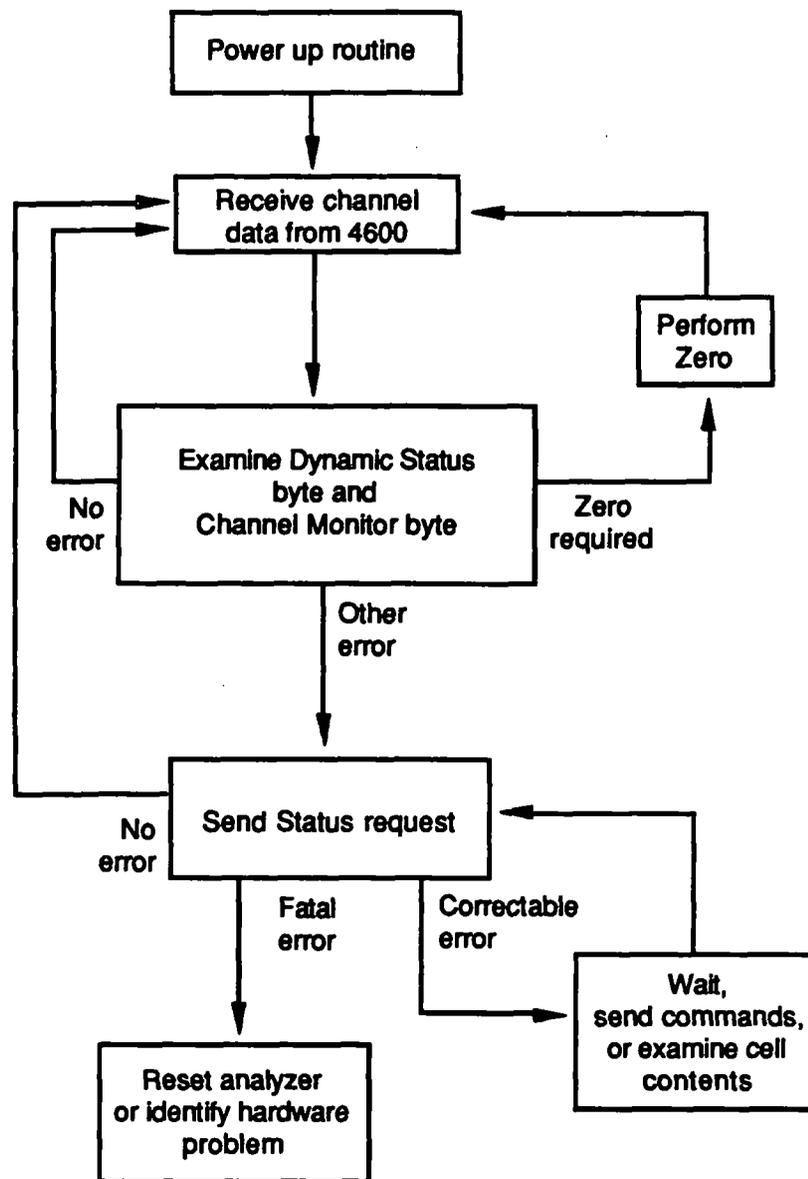


Figure 5-4. Error handling flowchart

5.6.3. Corrective action

The actions taken by the host to clear a correctable error generally fall into three categories:

- Wait
- Issue appropriate commands
- Examine the contents or pressure of the sample cell

These actions are described in detail in Appendix B for each correctable error.

Error messages requiring a Zero may be corrected by performing the Zero routine. This also results in the Check Status flags being reset. If Span errors are reported, it is recommended that the Calibration gas be checked for content and concentration. Incorrect span gas can cause the 15% span change limit to be exceeded.

Note that certain errors report out-of-range conditions in the measurement electronics. These errors include A/D Limit, Underrange and Overrange. Corrective action in this case is to examine the contents of the sample cell for incorrect gas type or concentration. An occlusion in the pneumatics circuit can also account for out-of-range error messages.

Note that Compensation errors such as Compensation O₂ Invalid will be flagged when a failure in one channel affects the accuracy of another channel. In this case the original failure occurred in the O₂ channel, but the CO₂ channel is also flagged invalid. The corrective action is to clear the failure in the O₂ channel. The Compensation O₂ flag appearing in the CO₂ channel will also be reset.

SECTION 6 COMMUNICATIONS PROTOCOL

6.1 COMMUNICATIONS OVERVIEW

The host computer transmits commands to the 4620 as a series of bytes, and receives a series of bytes in response. In order for the 4620 communications program to decode these commands, the structure of the command packet must be correct.

After a communication is received, it is examined by the 4620 and one of three actions may be taken: ACK, NAK or no response. These responses are described in this Section.

6.2 NOTATION

The following mnemonics are used to identify individual bytes in the 4620 command and response descriptions.

ACK	Acknowledged
ADR	Address in NOVRAM
AS	Activate solenoid
CD	Channel descriptor
CH	Channel data
CHM	Channel mask byte
CMD	Command number byte
CS	Checksum
DF	Data Field (general)
EC	Error code
LB	Length byte
NAK	Not acknowledged
O2	Digital O2 value
P	Pressure
PS	Pump select
REV	Revision level code
SF	Status field
SN	Serial number
SCM	Span channel mask
TV	Tag value
TVM	Tag value mask
VC	Vendor code

Additional symbols used in the following sections include:

- \$XX When the contents of a byte can be explicitly stated, it is written in standard hex notation. For example, the symbol \$A1 represents the binary expression 10100001.
- [] Enclosed items may appear zero, one, or more times.
- Separator symbol between bytes.

The following is an example of a command issued to the 4620:

\$10 - \$01 - \$40 - CS

In this case the host transmits the Device Identification number (hex value \$10), followed by the hex values \$01 and \$40, followed by the Checksum byte. As is described in Appendix A, this is the command to transmit one set of channel data.

6.3 COMMAND STRUCTURE

A command to the Model 4620 consists of from four to thirteen bytes. The general format for a command is as follows:



Where,

- DID represents the device identification number (for the Model 4620 this number is fixed at \$10)
- LB is a length byte containing the number of bytes to follow, excluding the checksum byte (\$00 is valid)
- CMD is the command byte
- [DF] is an optional data field that varies in length from command to command
- CS is the checksum

The checksum is computed as follows:

$$CS = \text{not} (DID + LB + CMD + [DF]) + 1$$

This is equivalent to a modulo 256, 2's compliment of the sum of the bytes in the command.

6.4 RESPONSE STRUCTURE

A 4620 response consists of from five to seventeen bytes. The general format for a response is:

ACK/NAK	CMD	DS	LB	[DF]	CS
---------	-----	----	----	------	----

Where,

ACK/NAK	is a byte indicating whether the command was received without error (Acknowledged/Not Acknowledged)
CMD	indicates the command being responded to
DS	is a dynamic status byte indicating current system status and operating mode
LB	is a length byte containing the number of bytes to follow, excluding the checksum byte (\$00 is valid)
[DF]	is an optional data field that varies from command to command
CS	is the checksum

The checksum is computed as follows:

$$CS = \text{not} (ACK/NAK + CMD + DS + LB + [DF]) + 1$$

As was described in Section 6.3, this is equivalent to a modulo 256, 2's complement of the sum of the bytes in the command. Note that the the checksum is a fixed value for most responses. This value is shown in the command list found in Appendix A. The command list describes the ACK response and the NAK response for each command.

6.4.1 No Response

There are a number of conditions which result in a checksum error, for which the 4620 will issue no response:

- Incorrect device ID
- Incorrect length byte or length byte greater than 16
- Incorrect checksum

Any of the above conditions will result in transmission errors, causing the checksum byte to be incorrect. If no response is received from the 4620 within a five second period after sending a command, it may be assumed that transmission errors have occurred. The host should automatically retry the transmission. In this case the 4620 will continue to examine incoming data for a legitimate device ID byte, and will then examine subsequent bytes for a valid command number.

6.4.2 ACK

When the 4620 receives a command correctly, an ACK response is generated. An ACK response always contains hex value \$06 in the first byte and follows the general response structure. The transmission requirements described above must be met to generate an ACK, in addition to the following:

- The command byte must be **recognized**, that is, it must be listed in the command set.
- The command must be **allowed** at the time, for example, a Zero command may not be sent during the Span routine.

Receipt of the ACK response does not necessarily indicate that the command has completed execution, as shown for certain commands in Appendix A. The exact format of the ACK response for each command is described in the command list.

6.4.3 NAK

If the transmission requirements described in Section 6.4.1 are met, but the command is not recognized or allowed, a NAK response will be generated.

The NAK response format contains six bytes and always contains hex value \$15 in the first byte. It is a special case of the standard response format and appears as follows:

\$15	CMD	DS	\$01	EC	CS
------	-----	----	------	----	----

The NAK error codes found in byte EC are as follows:

<u>Hex</u>	<u>Decimal</u>	<u>Cause of error</u>
00	00	System Fault
10	16	Incorrect command length
20	32	Span in progress
22	34	Zero in progress
40	64	Bad channel selection (Span mode)
42	66	Tag value out of limits (Span mode)
46	70	Can't span digital O2 (Span mode)
48	72	Channel data out of range (Span mode)
4E	78	Continuous transmission in effect (Transmit 1 data set)
50	80	Write NOVRAM failure (Write NOVRAM)
52	82	Address out of bounds (Write NOVRAM)
54	84	Configuration specified and not in SMODE (Write NOVRAM)

6.4.4 Dynamic Status Byte

This byte is returned for all 4620 responses. It is intended to supply the host computer with basic 4620 status information without the necessity of issuing a Status Request command (\$01).

Note that the Mode bits (3-5) are useful to determine which command set is currently allowed by the 4620.

This byte is also described in the Status word foldout in Appendix B.

Dynamic status byte (DS)

This byte contains the following bits:			
	<u>Bit</u>	<u>Status code</u>	<u>Description</u>
MSB:	7	00	System fault self test (1 = fault)
	6	01	Mode (3 bits) 000 = Normal 001 = Zero 011 = Span in progress 100 = Filter wheel timing fault
	5	.	
	4	.	
	3	04	Warmup timer counting
	2	05	Zero required
	1	06	Occluded
LSB:	0	07	Check Status

SECTION 7

TEST AND INSPECTION

7.1 INTRODUCTION

This section contains two suggested test procedures: one for incoming inspection of the Model 4620, and one for troubleshooting an inoperable unit.

7.2 INCOMING INSPECTION

7.2.1 Scope

This procedure applies to the Model 4620 CO₂ / N₂O analyzer. Testing is at the analyzer level; it does not include other subsystem components such as pneumatic assemblies and power supplies.

7.2.2 Purpose

This procedure is intended to provide a limited functional test of the Model 4620 for purposes of incoming inspection prior to integration into the host system. It exercises the main functions of the analyzer in approximately 2 to 5 minutes with a minimum of test equipment. No gases are required. The short duration of the test is intended to allow 100% testing of incoming units.

7.2.3 Test Equipment

- Power supply, current limited
- IBM or compatible computer with RS232 Communication Port
- Computer program, as described below

7.2.4 Test Program

This program is written by the customer and sends only three commands to the analyzer. When directed by the test operator it issues the following commands:

- Status request (\$01)
- Transmit Channel Data, Continuous (\$43)
- Zero (\$20). Note that minimum purge time is required (e.g. 001)

The program should display the following information:

- In response to Status, the contents of the Status Field (see Appendix B)
- In response to Transmit Data, the contents of the returning data packets

7.2.5 Visual Check

Carefully inspect the entire analyzer for loose or missing screws, missing or mis-inserted jumpers, damaged cable, improperly inserted sample cell, or incorrect serial number tag.

7.2.6 Set up

Set up the test equipment as shown in Figure 7-1.

(Begin test cycle)

With power off, plug the Model 1101 power supply into P3 on the 4620 SMR board. (See figure 4-1 in this manual.) Connect the serial interface to P2 on the Processor board.

Apply power. In approximately 10 seconds the Head assembly motor should be heard as it begins to turn. The motor speed will increase and stabilize as it is controlled by the motor servo circuit. If the motor "runs away" discontinue the test.

Initiate the test program.

7.2.7 Status response

Instruct the test program to issue a Status request (\$01). If a Status word is not returned, or if any of the following error conditions are observed in the Status Field, reject the unit under test:

7.2.8 Response to Transmit Data

Instruct the test program to issue a Transmit Channel Data, Continuous command (\$43). If channel data is not received, reject the unit. At this point the analyzer has not been Zeroed; therefore the concentration values received are not significant.

In order to establish that the channel data is reasonably accurate, perform the following sequence: Allow the analyzer to warm up for approximately two minutes. Instruct the test program to issue a Zero command. Inspect the data after the routine is completed. If it is not within the following values, reject the unit:

- N2O channel: $0 \pm 5.0 \%$
- CO2 channel: 0 ± 20 Torr
- Pressure channel: Ambient pressure ± 20 Torr

Since the analyzer is warming up, it is necessary to inspect the data immediately after the Zero routine is completed. The test technician can determine when the Zero routine is completed by examining the Dynamic Status byte returned with the channel data. The Mode bits will indicate when the analyzer has returned to Normal mode.

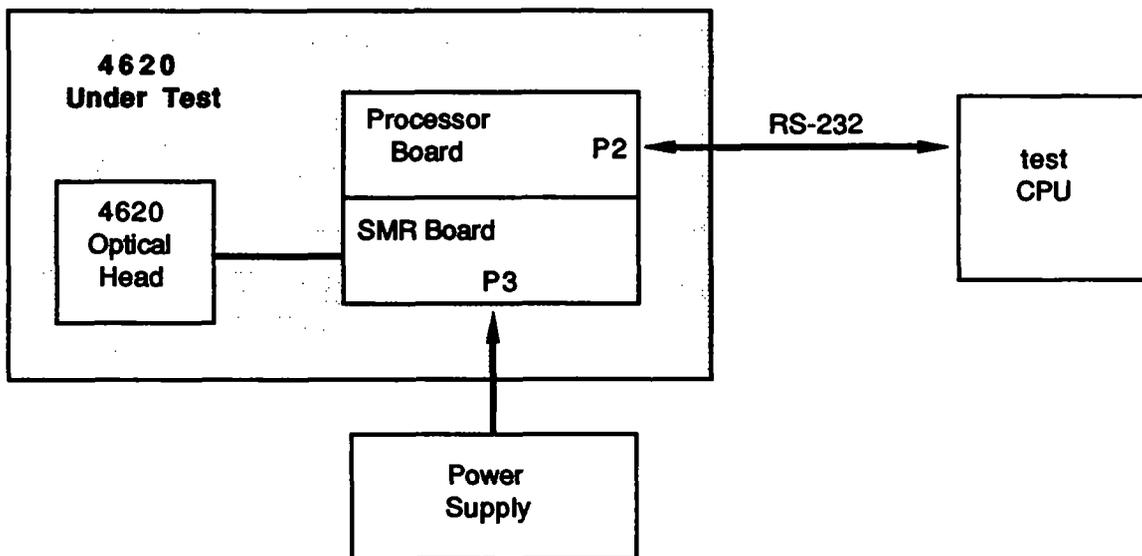


Figure 7-1. Test and Inspection Set up

7.3 TROUBLESHOOTING

7.3.1 Purpose

This section describes how to troubleshoot the Model 4620 to determine if the analyzer is faulty. There are very few parts on the 4620 that are user replaceable. The primary purpose of this procedure is to 1) determine if a malfunction exists and 2) identify any problems that can be solved by the user before sending the analyzer to an Andros service depot. See also Maintenance Philosophy, Section 1.2.

Note that if the analyzer is faulty, the complete unit must be returned to the service depot. This test does not identify the fault to the component level (head, electronics, etc), as these components are not replaceable or interchangeable in the field.

If the analyzer is returned to the service depot, please complete the form at the end of this Section, indicating where the failure occurred in the troubleshooting procedure.

7.3.2 Test Equipment and test program

The equipment and the computer program used in the Incoming Inspection, Section 7.2, are also used in this procedure.

7.3.3 Visual Check

Carefully inspect the entire analyzer for loose or missing screws, missing or mis-inserted jumpers, damaged cable, misinserted sample cell, or incorrect serial number tag.

- √ All of the above faults are customer correctable. If any of the above parts are not functional, replace or repair them.

7.3.4 Set up

The set up is identical to the Incoming Inspection. If the analyzer passes visual inspection, connect it to the test set up shown in Figure 7-1.

7.3.5 Power up

With no analyzer connected, ensure that the power supply voltage is within specifications. Connect the analyzer and apply power. In approximately 6 seconds the Head assembly motor should be heard as it begins to turn. The motor speed will increase and will stabilize as it is controlled by the motor servo circuit. If the motor "runs away" discontinue the test.

- √ If the motor fails to turn, check the following:
 - Cable from head to electronics
 - Motor leads and connector

- √ If no faults are found and motor continues to malfunction, return the analyzer to an Andros repair station.

7.3.6 Communication test

If the motor runs and stabilizes, initiate the test program.

- √ If no response is received, check the serial connection between the analyzer and the computer

- √ If no faults are found and there is no response or improper response, return the analyzer to an Andros service depot.

7.3.7 Fatal errors

If the analyzer communicates properly, examine the Status word to determine whether a fatal error is reported. The System Fault - Self Test bit (Status code 00) should be examined. If this bit is high a fatal error occurred during the Self Test routine during turn on. The following bits should be examined:

- √ Pressure range fail (Status code 27). If the sample cell is at atmospheric pressure and this bit is set, then there is probably a fault in the pressure signal processing circuit. Recalibration of the pressure circuit may clear the error. See Section 5.4.5.
- √ NOVRAM Fail (Status code 12). Return analyzer to an Andros service depot.
- √ RAM Fail (Status code 13). Return analyzer to an Andros service depot.
- √ ROM Fail (Status code 14). Return analyzer to an Andros service depot.
- √ Processor Fault (Status code 15). Attempt to reset the analyzer. If the fault does not clear, return analyzer to an Andros service depot.

7.3.8 Troubleshooting report

In the event that it is necessary to return a Model 4620 to the service depot, please duplicate this form and indicate at which point in the procedure the failure occurred. In addition, if known, please describe the conditions during which the failure was first observed.

Troubleshooting report

- 1. Company _____
- 2. Date _____
- 3. Model/Serial No. _____
- 4. Date purchased _____
- 5. End-user application _____

Failure observed during:

Power up. Motor failure _____
 Motor runs away _____

Communication test. No response _____
 Improper response _____

Fatal error Pressure range _____
 Power failure _____
 NOVRAM failure _____
 RAM failure _____
 ROM failure _____
 Processor failure _____

Other _____

Observations:

SECTION 8 OPTIONAL HARDWARE

This section contains information on the Model 1401 Pneumatics Assembly. This unit is available from Andros to simplify integration of the 4620 into the host system.

**Note: The following Model 1401 data is Preliminary.
Consult Andros Analyzers for most recent information.**

8.1 Model 1401 - General

The Model 1401 Pneumatics Assembly is designed to operate with the Andros line of Anesthetic Agent/Capnometer analyzers and performs the following functions:

- In patient mode, delivers constant gas flow to the analyzer.
- In zero mode, delivers zero gas to the analyzer and provides high flow rate to shorten sample cell purge time.
- Provides pump on/off control.

The pneumatics assembly consists of a flow rate sensor, a servo-controlled pump, a solenoid valve, and the necessary interface electronics. Four selectable flow rates are available to the user.

Subsystem available: The unit is available individually or as a part of the 4862 Subsystem. The complete subsystem consists of three components designed to simplify integration into the host system: the Model 4620 Analyzer, a power supply, and the 1401 Pneumatics Assembly.

The pneumatic flow diagram given below illustrates the gas flow path through the pneumatics assembly and the 4620. As shown, the sample gas from the patient passes through the solenoid, then through the sample cell and the flow sensor assembly, and finally through the pump to the exhaust. During the autozero process the solenoid is switched to a source of zero-gas.

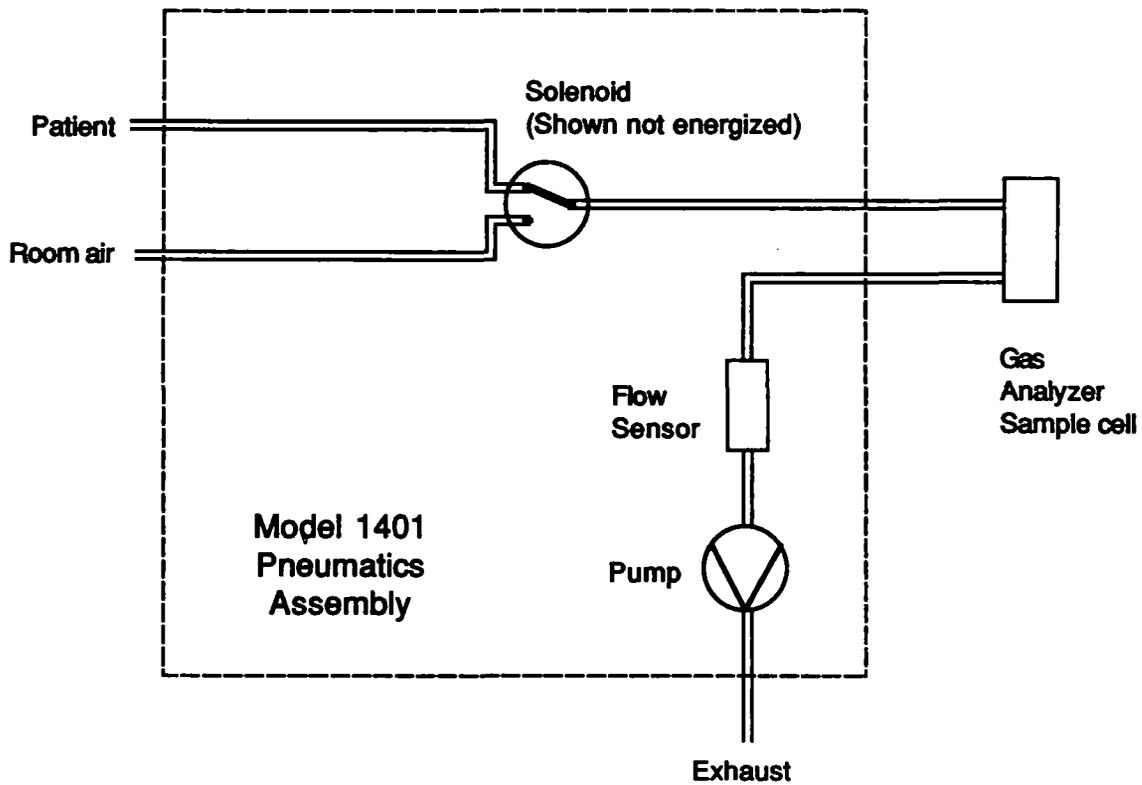


Figure 8-1. Pneumatic Flow Diagram

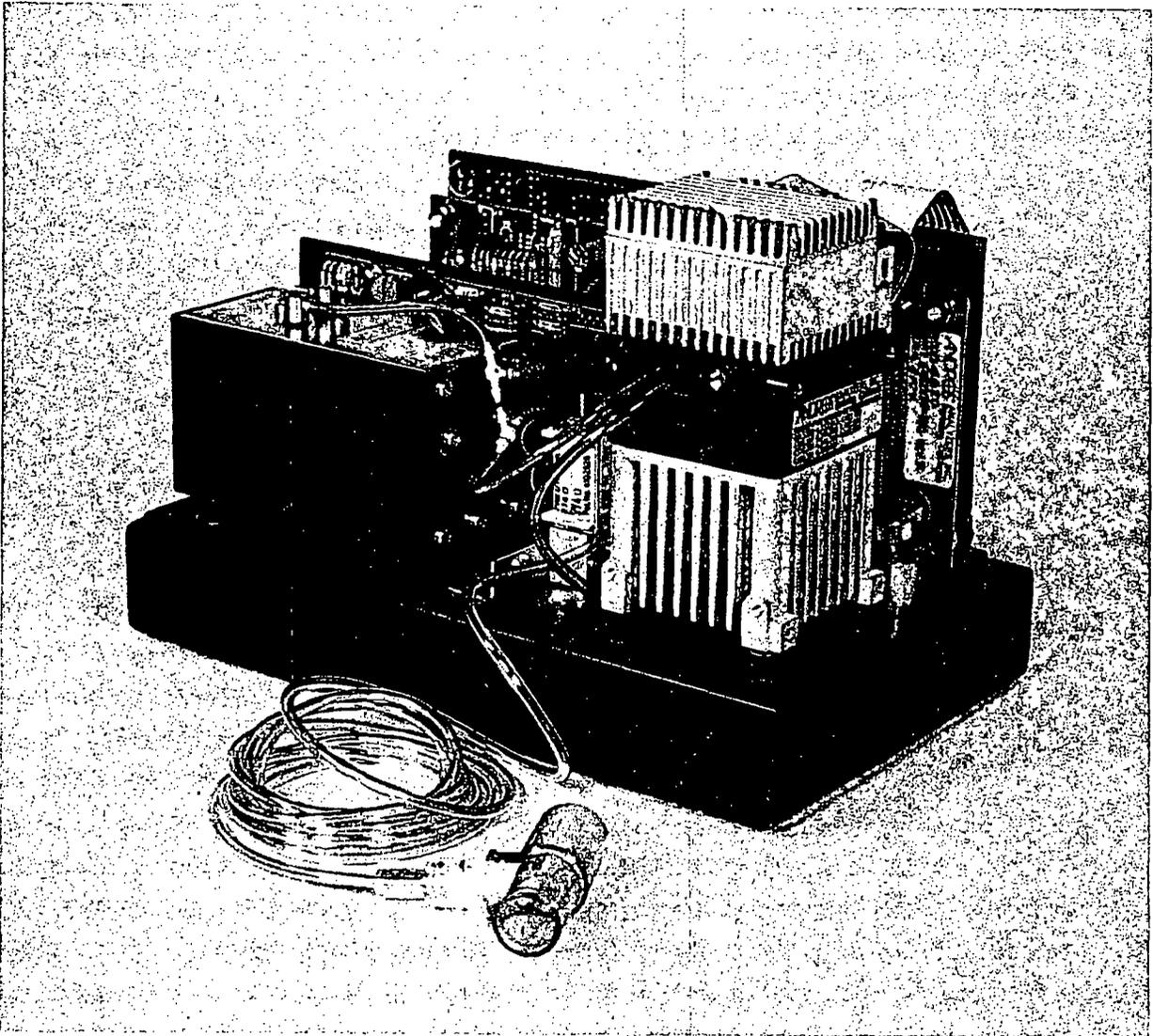


Figure. Model 4862 Subsystem

8.2 Interfacing the 1401

Pneumatics: Pneumatic lines to the 1401 are connected as shown in Figure 8-2 and include the following:

- Patient sample gas line in
- Room air line in
- Two sample cell lines
- An exhaust line

Logic: Electrical connections are made to connector J1 on the 1401 PC board, as shown in Figure 8-3. All control inputs are TTL compatible. The Model 4620 Gas Analyzer normally drives pins 11 through 14. The 1401 issues a single logic output, the Occluded line. This line is described in Section 8.5.

Power: Power connections are also made to connector J1. Although separate power supplies may be used, the Pneumatics Assembly is designed to take its power directly from the 4620 analyzer. Since the 4620 generates multiple output voltages used by the pneumatics assembly, only one supply voltage is required from the host. Note, however, that when driving a pneumatics assembly, the power required by the 4620 increases from 16 Watts to approximately 19 Watts. Under worst case conditions the total power dissipation for the 4620 is approximately 25 Watts.

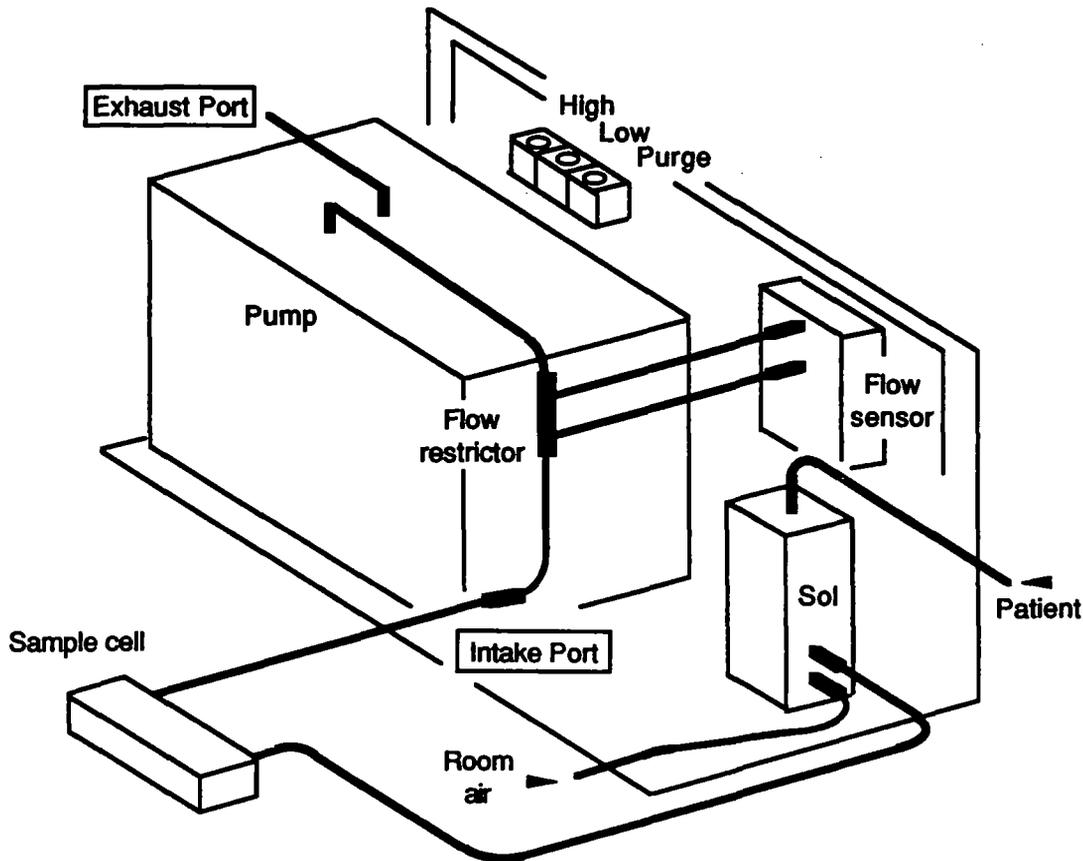


Figure 8-2. Front View, Simplified

8.3 Solenoid Control

The solenoid valve is controlled by a TTL logic level signal that is supplied to J1 on the 1401. This line is shown in figure 8-3, and is labelled "Patient/zero".

The sense of the solenoid control line is as follows during normal operation and Zero:

<u>Condition</u>	<u>Status of TTL line</u>
Sample Patient	0
Sample Room Air	1

8.4 Pump Control

The servo-controlled pump has four selectable flow rates. A differential pressure sensor monitors the pressure drop across an orifice and maintains flow within 10% over varying conditions of flow restriction and ambient temperature. Flow restriction in the sample circuit depends on length and diameter of the tubing, and the type of filters used. It also varies as occlusions occur.

The 1401 maintains the desired flow rate until pressure at the intake port drops 6 inches of Mercury below that of the exhaust port. This assumes that the exhaust port is at or near ambient pressure. The location of these ports is identified in Figure 8-2. If the pressure difference exceeds 6 inches of Mercury the 1401 asserts the Occluded signal.

The flow rate is selected through J1 pins 8 and 10, as shown in Figure 8-3. The two TTL inputs have the following sense:

<u>State</u>	<u>Nominal flow rate</u>	<u>Pump 1 line</u>	<u>Pump 0 line</u>
Purge flow rate	350 ml/min	0	0
High flow rate	200 ml/min	0	1
Low flow rate	65 ml/min	1	0
Pump off	0 ml/min	1	1

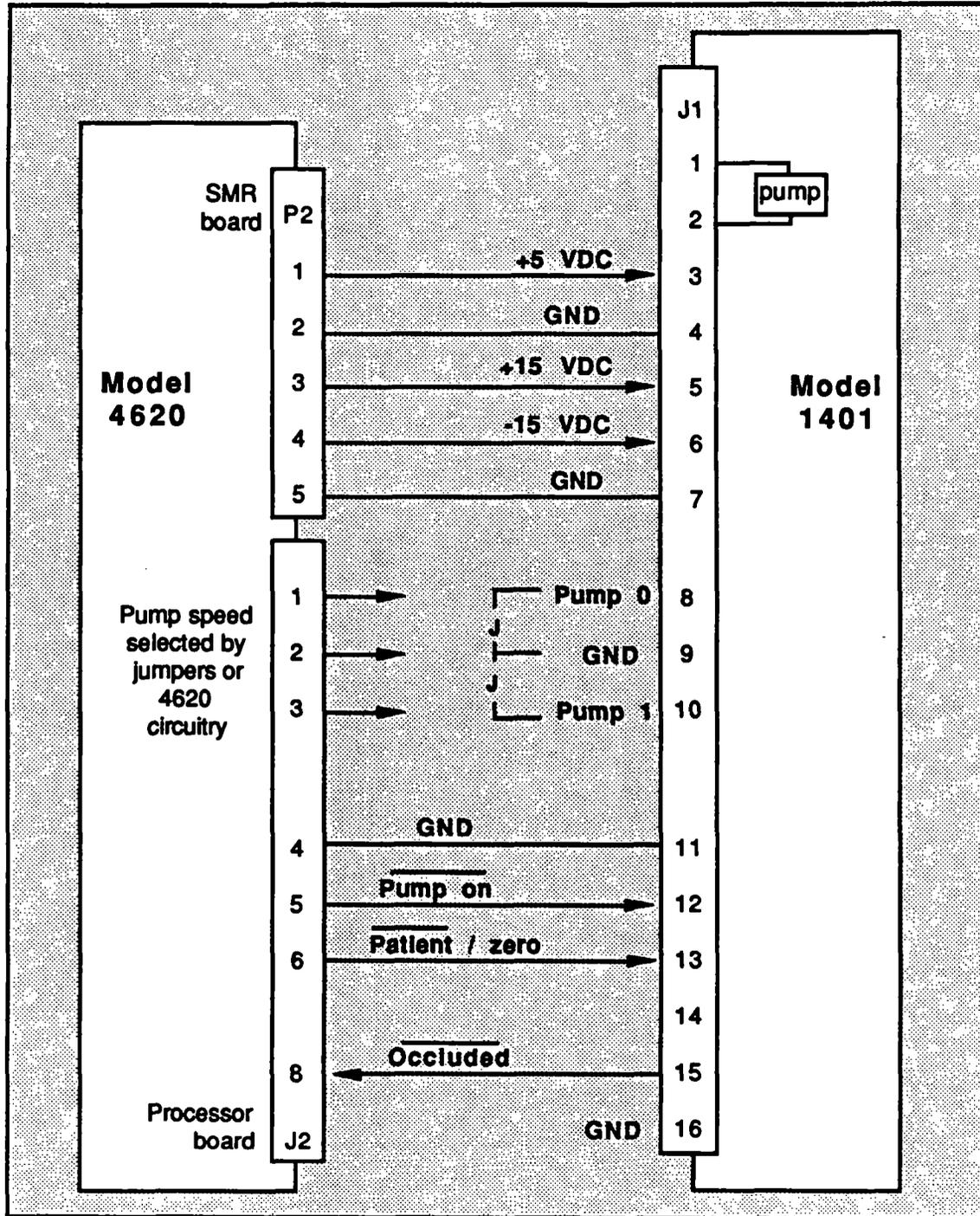


Figure 8-3. Interconnect Diagram

8.5 Occluded signal

The Occluded signal appears on pin 15 of J1 and is an open collector output. The signal is processed by the 4620 and its status is reported in the 4620 Status word.

8.6 Power Requirements

The Model 1401 requires three power supply rails. These voltages are available from the 4620 analyzer; however, if the user prefers to provide independent power supplies, the following specifications apply.

Worst case: These supply currents are worst case and occur during purge mode, with high restriction, and with the solenoid energized.

<u>Voltage</u>	<u>RMS Current</u>
+15 VDC	625 mA
-15 VDC	50 mA
+5 VDC	100 mA

The +15 Volt supply must be capable of driving inductive loads. High current pulses occur at a nominal 130 Hz rate. For worst case conditions they are approximately equal to the following values:

peak positive (out of supply)	850 mA
peak negative (into supply)	350 mA

Typical: Typical operating current for the +15 Volt supply with the solenoid not energized is as follows:

50 ml flow rate:	50 mA
200 ml flow rate:	130 mA
400 ml flow rate:	250 mA

The pin out for power connections is shown in Figure 8-3 (Interconnect Diagram).

8.7 Calibration

Like most flow measuring devices, the 1401 flow controller controls the mass flow of the gas being pumped. As the gas mixture changes, the actual volumetric flow will change in proportion to the change in molecular weight of the mixture.

In most applications, the purpose of flow control is to ensure a minimum flow rate that will yield the specified response time of the measuring instrument. Calibrating the flow for the heavier gas mixtures results in increased flow rate for lighter gas mixtures and ensures adequate response time.

As shipped, the 1401 is calibrated for 350, 200, and 65 ml/min flow rate using air at sea level. These flow rates may be adjusted by the user by adjusting the potentiometers shown in Figure 8-2. Note that the upper flow rate may be increased substantially if desired; however, power dissipation in this mode also increases due to the additional pump load.

The 1401 should be calibrated at the altitude of use, using a lab grade rotometer accurate to $\pm 2\%$ full scale. The rotometer should have calibration tables for atmospheric pressure, temperature and gas type.

Note that the purge rate adjustment (nominally 350 ml/min) affects the remaining two settings. Therefore the purge rate must be set first. The 200 and 65 ml/min flow rates may then be set in either order.

If the 1401 is calibrated with a gas heavier than air, the resulting flow rate when operating with air would increase. Suppose for example the 1401 were calibrated with a gas mixture composed of 5% CO₂, 60% N₂O and 35% O₂. This mixture would be among the heaviest encountered in typical use. If the mixture were changed to room air, the volumetric flow rate would increase to approximately 300ml/min.

The user may adjust the flow rate to nominal (200 ml/min or 65 ml/min) for any physiologic gas mixture desired. R5 and R6 adjust the flow rates for the 1401.

8.8 Routine Maintenance

Pneumatic system maintenance is a concern when line filters are used in the application. Consult Andros Analyzers for information on maintenance.

APPENDIX A COMMAND LISTING

<u>Code</u>	<u>Command</u>
\$00	Self test
\$01	Status
\$02	Return Vendor ID & Software Revision
\$04	Return Device Serial Number
\$10	Receive Gas Values
\$11	Receive O ₂ Data
\$12	Output Filter Control
\$13	CO ₂ Format Control
\$20	Zero
\$22	Reset Span
\$40	Transmit Channel Data, 1 Set
\$43	Transmit Channel Data, Continuous
\$44	Stop Continuous Data Transmission
\$48	Return Temperature Data
\$62	Pump Control
\$D2	Compensated Readings
\$D3	Uncompensated Readings
\$D4	Toggle O ₂ /ref
\$E1	Solenoid Control
\$F0	Reset

\$00

Self Test

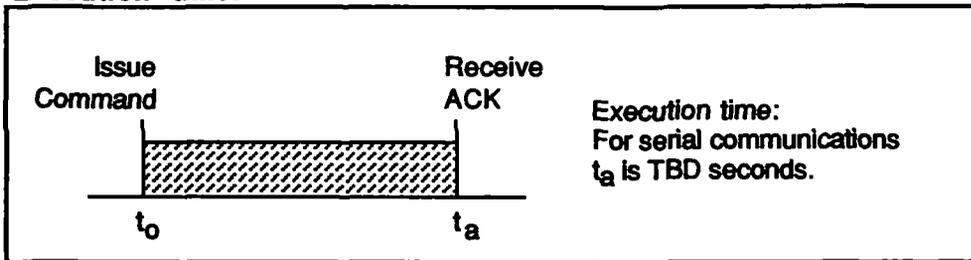
Command: \$00 - Self Test
Command Format: \$10 — \$01 — \$00 — \$EF
4620 ACK format: \$06 — \$00 — DS — \$00 — CS
4620 NAK format: \$15 — \$00 — DS — \$01 — \$00 — CS

Description: The analyzer is instructed to do a Self Test sequence.

The test consists of the following items: NOVDRAM, RAM and ROM. If any test fails, the appropriate bits are set in the Status Field (see Appendix B). In addition, the System Fault and the Check Status bits are set.

When the sequence is complete, the analyzer places itself in the mode in effect at the time of the command.

Execution time:



Error codes: A NAK response is never returned because the Status command is always allowed.

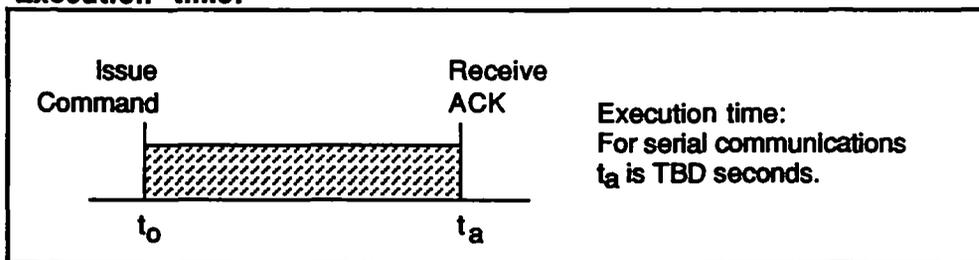
\$01

Status

Command: \$01 - Return analyzer status
Command format: \$10 — \$01 — \$01 — \$EE
4620 ACK format: \$06 — \$01 — DS — \$0C — SF1 — SF2 — SF3 — SF4 — CD1 — CD2 — CD1 — CD2 — CD1 — CD2 — CD1 — CD2 — CS
4620 NAK format: Not applicable (The NAK production is never returned because Status is always available.)

Description: The analyzer is instructed to return general status information.

Execution time:



DS, SF and CD bytes:

The Dynamic Status, Status Field and Channel Descriptor bytes are described in Appendix B of this manual.

Error codes: A NAK response is never returned because the Status command is always allowed.

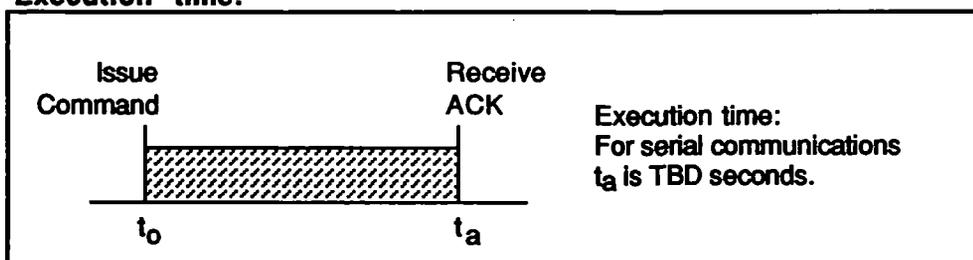
\$02

Return Vendor ID & Software Rev.

Command \$02 - Return Vendor ID & Revision Level
Command Format: \$10 — \$01 — \$02 — \$ED
4620 ACK format: \$06 — \$02 — DS — \$07 — VC1 — VC2 — VC3 — VC4 — VC5 — VC6 — REV1 — CS
4620 NAK format: \$15 — \$02 — DS — \$01 — \$00 — CS

Description: The analyzer is instructed to return the Vendor ID code and the software Revision Level.

Execution time:



Vendor Code bytes (VC1 – VC6)

The vendor code is returned as six ASCII characters:

<u>Vendor Code</u>	<u>Description</u>
"ANDROS"	Andros Analyzers, Inc.

Revision Level bytes (REV1 – REV2)

The revision level code is returned as two ASCII characters:
REV1 is the most significant byte; REV2 is least significant.

<u>Revision Code</u>	<u>Description</u>
"##"	"##" represents the code for the software revision level. If numeric, the software is prototype. If alphabetic, the software is a released version.

Error codes: The only condition that will return a NAK response is a system fault (EC byte = \$00).

\$04

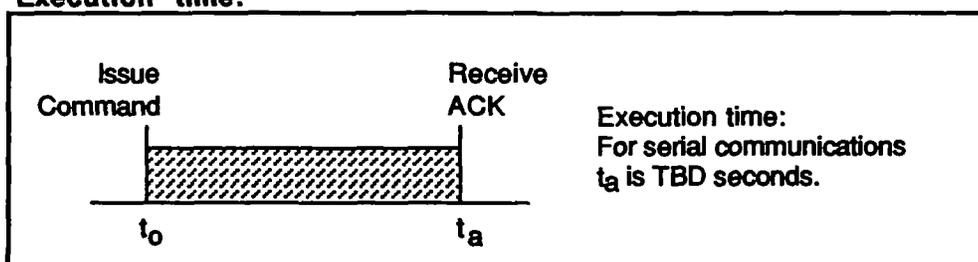
Return Device Serial Number

Still needed? \$10

Command: \$04 - Return Device Serial Number
Command Format: \$10 — \$01 — \$04 — \$EB
4620 ACK Format: \$06 — \$04 — DS — \$06 — SN1 — SN2 —
 SN3 — SN4 — SN5 — SN6 — CS
4620 NAK Format: \$15 — \$04 — DS — \$01 — \$00 — CS

Description: The analyzer is instructed to return the analyzer serial number.

Execution time:



Serial Number byte (SN1 - SN6)

The serial number code is returned as six ASCII characters. SN1 is the most significant byte; SN6 is least significant.

<u>Serial number code</u>	<u>Description</u>
"#####"	Analyzer serial number

Error codes: The only condition that will return a NAK response is a system fault (EC byte = \$00).

\$10

Span

Command: \$10 - Span
Command Format: \$10 — LB — \$10 — TVM — TV1 — TV2 —
[TVM — TV1 — TV2] — CS
4620 ACK Format: \$06 — \$10 — DS — \$00 — CS
4620 NAK Format: \$15 — \$10 — DS — \$01 — EC — CS

Description: Informs the analyzer that calibration gas is present in the sample cell and instructs the analyzer to begin calibration of one or more gas channels. No additional commands are required to complete the Span procedure for the channels specified.

The host must include from one to three tag values with this command, and the tag values may be positioned in any order in the command. If a "cocktail" mixture is specified, the command needs to be issued only once. If individual binary gases are used, the \$10 command must be issued for each channel to be calibrated.

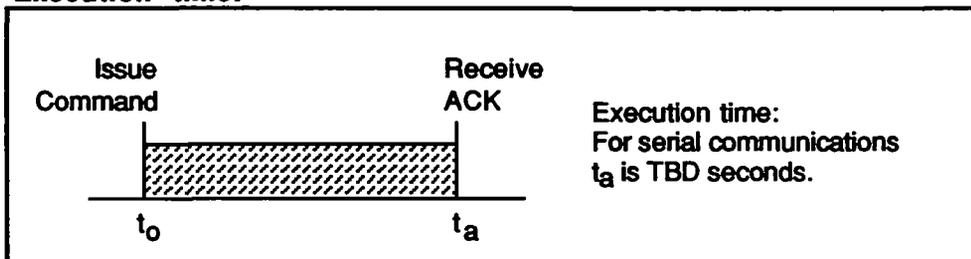
If the command is properly formed, the 4620 responds with the ACK production. The values obtained during the span procedure must be within the following factory settings:

N2O, CO2: ± 25%
O2: + 0, - 68%

If they are not, the Span Fail bit is set in the appropriate channel status. Also note that if NOVRAM failure causes the Span information to be written improperly, the failure will not be indicated by a NAK response, but will be flagged in the Status response.

A NAK response will be returned if a system fault is in effect, if Span is already in progress, if a Zero is in progress, if an invalid mask is sent, or if an invalid tag value is sent. The error is described in the Error Code byte EC.

Execution time:



Tag Value Mask (TVM)

The TVM byte identifies which gas channel is to receive the next two bytes of tag value data (TV1 and TV2).

MSB:	7	N/A
	6	N/A
	5	N/A
	4	N/A
	3	O ₂ *
	2	CO ₂ *
LSB:	1	N/A
	0	N ₂ O*

*Only one of these bits may be set high at a time

Tag Value bytes (TV1 and TV2)

Together these bytes make up a 16-bit number whose value is within the following range for each channel. TV1 is the most significant byte; TV2 is least significant.

<u>Channel</u>	<u>Range (decimal)</u>	<u>Concentration</u>
N ₂ O	200-1000	20 - 100.0 %
CO ₂	200-850	20 - 85 Torr
O ₂	150-1000	15 - 100.0 %

Error Codes (EC)

<u>Code (decimal)</u>	<u>Meaning:</u>
00	System Fault
32	Span already in progress
34	Zero in progress
64	Bad channel selection
66	Tag value out of limits
70	Can't span digital O ₂

\$11

Receive O2

Command: \$11 - Receive Digital O2 Values
Command format: \$10 — \$05 — \$11 — O21 — O22 —
P1 — P2 — CS
4620 ACK format: \$06 — \$11 — DS — \$00 — CS
4620 NAK format: \$15 — \$11 — DS — \$01 — EC — CS

Description: This command instructs the analyzer to ignore the O2 value derived from the oxygen sensor analog input and to use instead the value supplied in the command. The O2 value is used by the 4620 to perform interference corrections in the gas channels.

If the analyzer is capable of performing the procedure, the ACK is returned. If not the error code EC is returned in the NAK response.

The Oxygen values are supplied in bytes O21 and O22. Note that there are two additional bytes shown as P1 and P2 above. These bytes are not used by the 4620 and may contain any hex value.

O21 and O22

Together these bytes make up a 16-bit number whose value is within the range 0 to 100%.

<u>Range (hex)</u>	<u>Range (decimal)</u>	<u>Concentration</u>
\$0000 - \$03E8	0-1000	0 - 100.0 %

Note that a hex value of \$FF in both bytes instructs the analyzer to return to its default condition; that is, to use the O2 value derived from the oxygen sensor.

P1 and P2

Not used by the Model 4620.

Error Codes (EC)

<u>Code (decimal)</u>	<u>Meaning</u>
00	System Fault
16	Incorrect command length
32	Span in progress
34	Zero in progress
76	Digital O2 out of range

\$12

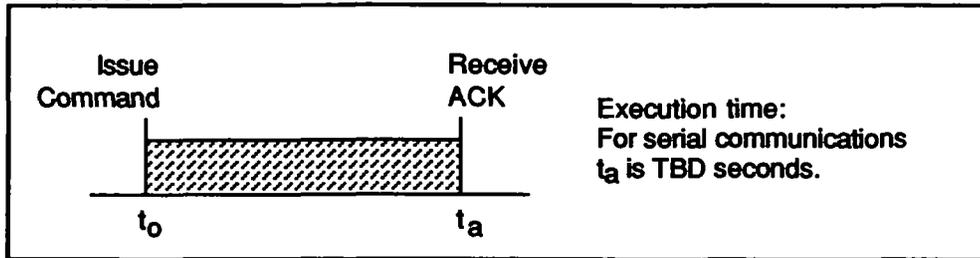
Output Filtering Control

Command: \$12 - Output Filtering Control
Command Format: \$10 — \$02 — \$12 — FC — CS
4620 ACK format: \$06 — \$12 — DS — \$00 — CS
4620 NAK format: \$15 — \$12 — DS — \$01 — \$EC — CS

Description: The analyzer is instructed to modify the output filter characteristics for CO₂ and N₂O channel data.

The default value for data filtering is presently an X-point running average. This command allows all data points to be transmitted without averaging.

Execution time:



Filter Control byte (FC)

<u>Code (decimal)</u>	<u>Meaning</u>
\$00	Default filtering
\$01	No output filtering

Error Codes (EC)

<u>Code (decimal)</u>	<u>Meaning</u>
00	System Fault
16	Incorrect command length

\$22

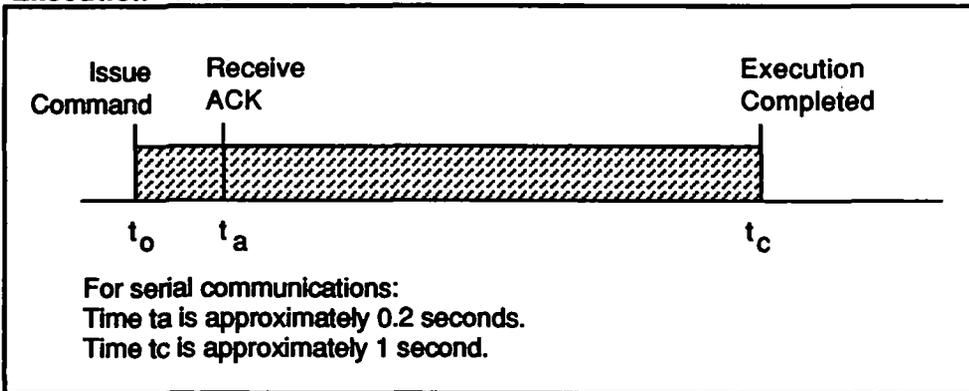
Reset Span

Command: \$22 - Reset Span values to nominal
Command Format: \$10 — \$02 — \$22 — SCM — CS
4620 ACK Format: \$06 — \$22 — DS — \$00 — CS
4620 NAK Format: \$15 — \$22 — DS — \$01 — EC — CS

Description: The analyzer is instructed to return the span values of the selected channels to the factory calibration settings.

An ACK is returned if the routine can be performed. If the routine cannot be performed, the NAK response is returned containing error code byte EC. Note that if NOVRAM failure causes the Span information to be written improperly, the failure will not be indicated by a NAK response, but will be flagged in the Status response.

Execution Time



Span Channel Mask (SCM)

Byte SCM specifies the channels to be reset.

MSB:	7	N/A
	6	N/A
	5	N/A
	4	N/A
	3	O ₂ *
	2	CO ₂ *
	1	N/A
LSB:	0	N ₂ O*

*One of or more of these bits may be set high simultaneously.
Bits identified by N/A will be ignored by the 4620.

Error Codes (EC)

<u>Code (decimal)</u>	<u>Meaning</u>
00	System Fault
16	Incorrect command length
32	Span in progress
34	Zero in progress

\$40

Transmit Channel Data, 1 Set

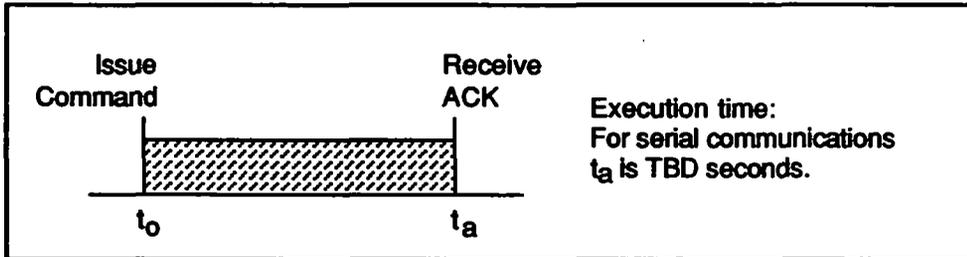
Command: \$40 - Transmit one set of data for all channels
Command Format: \$10 — \$01 — \$40 — \$AF
4620 ACK Format: \$06 — \$40 — DS — \$09 — CHK —
CH1 — CH2 — CH1 — CH2 —
CH1 — CH2 — CH1 — CH2 — CS
4620 NAK Format: \$15 — \$40 — DS — \$01 — EC — CS

Description: The analyzer is instructed to return one set of data for all channels. The analyzer responds with four channels of data issued in a single ACK response.

Gas concentration data is normally returned, unless uncompensated mode was previously selected (see commands \$D2 and \$D3). The ACK response shown above returns data for each channel preceded by the bit mask for that channel.

A NAK response is returned if continuous transmission (\$43) was previously requested, or if a system fault is in effect.

Execution time:



Check Data byte (CHK)

Byte CHK indicates which channels have a Check Data condition in effect. Any combination of bits 0 through 3 may be set high simultaneously.

MSB:	7	N/A
	6	N/A
	5	N/A
	4	N/A
	3	N ₂ O
	2	CO ₂
	1	O ₂
LSB:	0	Pressure

Channel Data (CH1 and CH2)

Together these bytes make up a single 16 bit number that represents channel data. CH1 is the most significant byte; CH2 is least significant. The channels are transmitted in the order shown in the following table.

For compensated data (assumes compensated mode was previously set as a default condition, or with command \$D2): The value returned represents gas concentration and will be within the following range for each channel. Note that negative concentrations are allowed so that negative drift may be reported.

<u>Channel</u>	<u>Range (decimal)</u>	<u>Concentration</u>
N ₂ O	-226 to 1000	-22.6 to 100.0%
CO ₂	-18 to 798	-1.8 to 79.8 torr
	-25 to 1050	-0.25 to 10.5%
O ₂	0 to 1024	0 to 102.4%
Pressure	0 to 1000	0 to 1000 torr

For uncompensated data (assumes uncompensated mode was previously set with command \$D3): This mode is used primarily for diagnostics. The value returned is the A/D converter count, with no corrections applied.

<u>Channel</u>	<u>Range (decimal)</u>	<u>Meaning</u>
N ₂ O, CO ₂	±4096	Reports A/D converter output.
Pressure	0-255	

Error Codes (EC)

<u>Code (decimal)</u>	<u>Meaning</u>
00	System Fault
16	Incorrect command length
78	Continuous transmission in effect

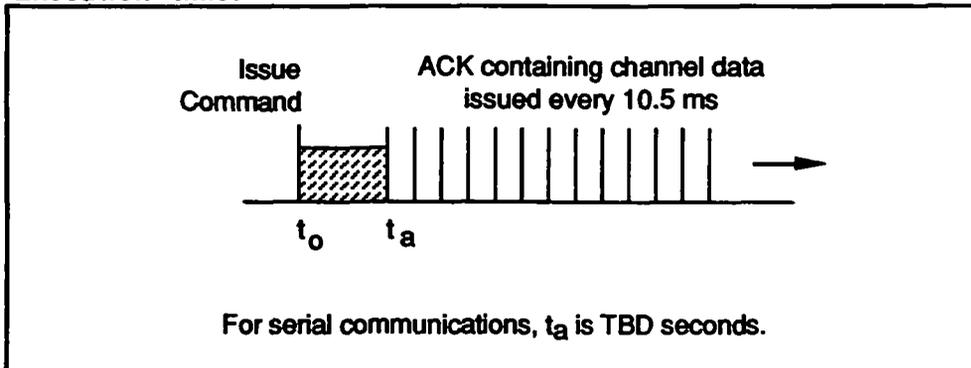
\$43

Transmit Channel Data, Continuous

Command: \$43 - Transmit continuous data for all channels
Command Format: \$10 — \$01 — \$43 — \$AC
4620 ACK Format: \$06 — \$43 — DS — \$09 — CHK —
CH1 — CH2 — CH1 — CH2 —
CH1 — CH2 — CH1 — CH2 — CS
4620 NAK Format: \$15 — \$43 — DS — \$01 — EC — CS

Description: The analyzer is instructed to return continuous data for all channels. Gas concentration data is normally returned, unless uncompensated mode is selected (see commands \$D2 and \$D3). The ACK response shown above returns data for each channel preceded by the bit mask for that channel. The response appears at 10.5 millisecond intervals until command \$44 is issued to cease continuous data transmission.

Execution time:



CHM and CH bytes:

The CHM and CH bytes are described under command \$40.

Error codes: The only condition that will return a NAK response is a system fault (EC byte = \$00).

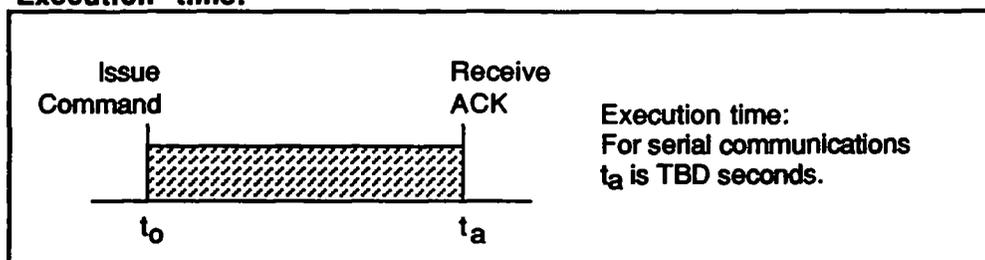
\$44

Stop Continuous Data Transmission

Command: \$44 - Stop Continuous Data Transmission
Command Format: \$10 — \$01 — \$44 — \$AB
4620 ACK Format: \$06 — \$44 — \$DS — \$00 — CS
4620 NAK Format: \$15 — \$44 — \$DS — \$01 — \$00 — CS

Description: The analyzer is instructed to stop continuous transmission of channel data (see command \$43).

Execution time:



Error codes: The only condition that will return a NAK response is a system fault (EC byte = \$00).

\$48

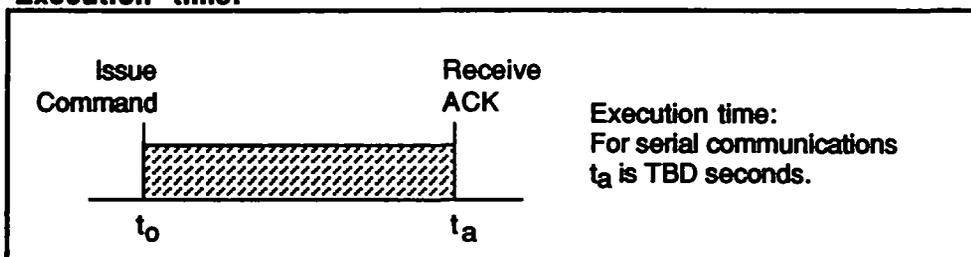
Return Temperature Data

Command \$48 - Return Temperature Data
Command Format: \$10 — \$01 — \$48 — A7
4620 ACK format: \$06 — \$48 — DS — \$02 — TD1 — TD2 — CS
4620 NAK format: \$15 — \$48 — DS — \$01 — \$00 — CS

Description: The analyzer is instructed to return ambient temperature as measured by a thermistor on the Processor board.

If the analyzer is in Compensated mode, the temperature will be returned in degrees Celcius. If it is in Uncompensated mode, the number of counts generated by the A to D converter is returned.

Execution time:



Temperature Data bytes (TD1 – TD2)

Together these bytes make up a 16-bit number.
TD1 is the most significant byte; TD2 is least significant.

Compensated mode:

Range (hex)	Range (decimal)	Temperature
\$0000 - \$03E8	0-1000	0 - 100.0 C

Uncompensated mode:

Range (hex)	Range (decimal)	A to D Counts
\$0000 - \$00FF	0-255	0 - 255

Error codes: The only condition that will return a NAK response is a system fault (EC byte = \$00).

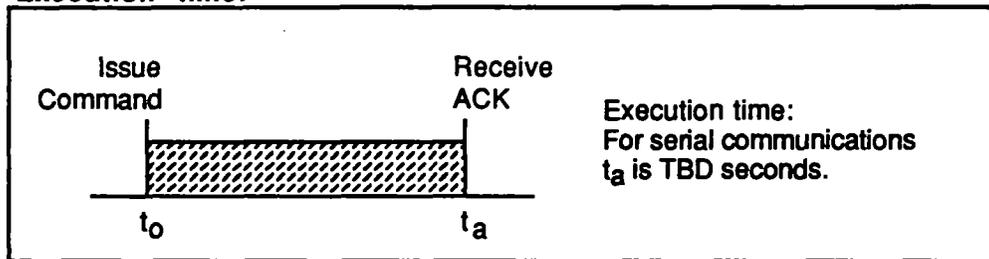
\$62 Pump Control

Command: \$62 - Set Condition of Pump
Command Format: \$10 — \$02 — \$62 — PS — CS
4620 ACK Format: \$06 — \$62 — DS — \$00 — CS
4620 NAK Format: \$15 — \$62 — DS — \$01 — EC — CS

Description: The analyzer is instructed to set the condition of the logic lines controlling the sample pump.

The analyzer returns the ACK response. The logic commands to the pneumatics assembly are set concurrently with the ACK response. In addition the appropriate status bits are also set (see Appendix B).

Execution time:



Pump Select byte (PS)

Meaning	Byte PS (Decimal)	4620 output			Status output	
		Pump 1	Pump 0	Pump $\bar{0}\bar{1}$	Bit 30	Bit 31
Flow rate purge	3	0	0	0	0	
Flow rate high	2	0	1	0	1	
Flow rate low	1	1	0	0	0	
Pump off	0	1	1	1	1	

Error Codes (EC)

Code (decimal)	Meaning
0	System Fault
16	Incorrect command length
32	Span in progress
34	Zero in progress

\$D2

Compensated Readings

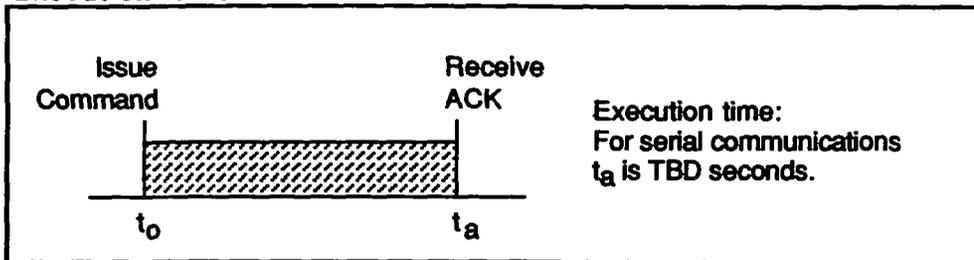
Command: \$D2 - Return compensated channel data
Command Format: \$10 — \$01 — \$D2 — \$1D
4620 ACK Format: \$06 — \$D2 — DS — \$00 — CS
4620 NAK Format: \$15 — \$D2 — DS — \$01 — \$00 — CS

Description: The analyzer is instructed to return channel data in compensated form. The analyzer returns an ACK response. The appropriate status bit is also set in the status field (see command \$01). This command sets the operating mode of the analyzer. It does not initiate data transmission.

Subsequent gas channel data, initiated by commands \$40 and \$43, will be in units of concentration, with all corrections applied.

\$D2 is normally required only if the analyzer was previously set to Uncompensated mode with command \$D3. The analyzer default condition on power up is compensated mode.

Execution time:



Error codes: The only condition that will return a NAK response is a system fault (EC byte = \$00).

\$D3

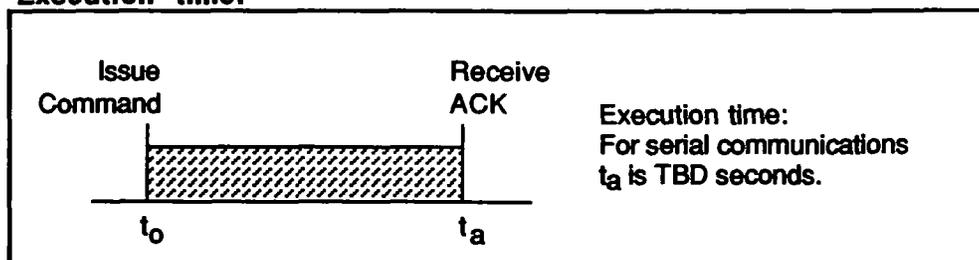
UnCompensated Readings

Command: \$D3 - Return all readings uncompensated
Command Format: \$10 — \$01 — \$D3 — \$1C
4620 ACK Format: \$06 — \$D3 — DS — \$00 — CS
4620 NAK Format: \$15 — \$D3 — DS — \$01 — \$00 — CS

Description: The analyzer is instructed to return channel data in uncompensated form. The analyzer responds with an ACK production. The appropriate status bit is also set (see appendix B). This command toggles the operating mode of the analyzer. It does not initiate data transmission.

Subsequent gas channel data, initiated by command \$40 or \$43, will report zero-normalized A/D converter output for all channels.

Execution time:



Error codes: The only condition that will return a NAK response is a system fault (EC byte = \$00).

\$D4

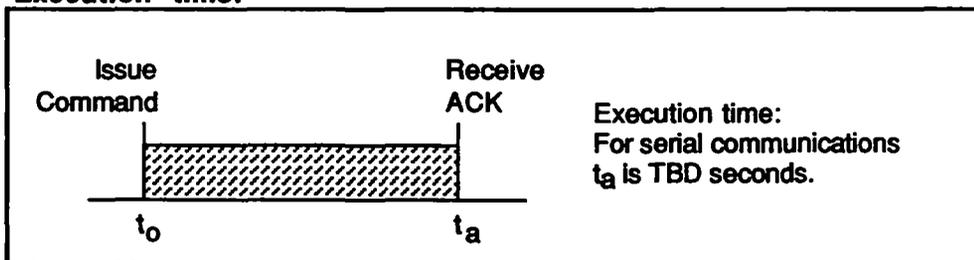
Toggle O2/ref

Command: \$D4 - Toggle O2/ref Channel
Command Format: \$10 — \$01 — \$D4 — \$1B
4620 ACK Format: \$06 — \$D4 — DS — \$00 — CS
4620 NAK Format: \$15 — \$D4 — DS — \$01 — \$00 — CS

Description: The analyzer is instructed to toggle the oxygen channel output between oxygen and reference. The reference output is used primarily for diagnostic purposes related to uncompensated data.

The analyzer responds with the ACK production. The appropriate bit in the Status field is set to indicate O2 or reference (see Appendix B). In addition the Check Data bit for the O2 channel is set if reference is selected.

Execution time:



Error codes: The only condition that will return a NAK response is a system fault (EC byte = \$00).

\$E1

Solenoid Control

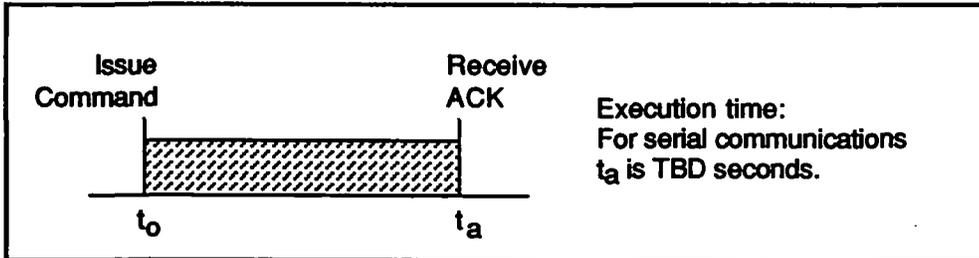
Command: \$E1 - Set Condition of Solenoids
Command Format: \$10 — \$02 — \$E1 — AS — CS
4620 ACK Format: \$06 — \$E1 — DS — \$00 — CS
4620 NAK Format: \$15 — \$E1 — DS — \$01 — EC — CS

Description: The analyzer is instructed to set the condition of the logic lines controlling the solenoids.

The analyzer returns the ACK response. The logic commands to the solenoids are set concurrently with the ACK response. In addition the appropriate status bits are also set (see Appendix B).

Note that the 4620 requires only one solenoid (Solenoid 1). An additional logic output (Solenoid 2) is provided for applications requiring the use of CO2 scrubbed air.

Execution time:



Activate Solenoid byte (AS)

Meaning	Byte AS (Decimal)	4620 output		Status output	
		Sol 2	Sol 1	Bit 45	Bit 44
Normal	0	0	0	0	0
Room air	1	0	1	0	1
Not used*	2	1	0	1	0
Scrubbed air*	3	1	1	1	1

*Note that the 4620 does not use these states.

Error Codes (EC)

<u>Code (decimal)</u>	<u>Meaning</u>
00	System Fault
16	Incorrect command length
32	Span in progress
34	Zero in progress

\$F0

Reset

Command: \$F0 - Reset
Command Format: \$10 — \$01 — \$F0 — \$FF
4620 ACK Format: \$06 — \$F0 — DS — \$00 — CS

Description: The analyzer is instructed to do a complete reset sequence, equivalent to a power-up reset.

This command is always allowed. An ACK will be returned if the reset is successfully initiated. During the time that the analyzer performs a self test and initialization procedure (several seconds), the serial link will be disabled and the analyzer will not respond to commands. Therefore, the host should expect no communication immediately following a reset.

Execution time: to be supplied

Error codes: A NAK response is never returned because the Reset command is always allowed.

2 0 Compensation on/off Correctable error

Sense: 1 = Uncompensated. (1 is the error condition). Indicates whether the channel data transmitted is compensated or uncompensated. Compensated data is gas concentration; uncompensated data gives pulse absorption and is used for troubleshooting only. Uncompensated mode sets the Check Status flag and all Channel Monitor bits. Corrective action is to set analyzer to Compensated with command \$D2.

2 4 Span Fail Correctable error

Sense: 1 = Fail. This bit is set if the 4620 attempts to change the span settings by more than $\pm 15\%$ from the factory settings during a span routine. It is also set if a system or a timing fault occurs during a Span routine. This bit sets the Check Status flag and the Channel Monitor bits for the applicable channels. The channels that failed are also reported by Span Fail bits in the Channel Descriptors, Status Codes 54, 74, and 94. Corrective action is to issue Reset Span command (\$22) or examine contents of sample cell and repeat the Span routine. This bit is not reset until all of the offending channels have been corrected.

2 5 Zero Fail Fatal error

Sense: 1 = Fail. Indicates that the 4620 is out of range in attempting to adjust the electronics to obtain a Zero setting. Also sets Status Code 32, the Check Status bit, and the Channel Monitor bits for the applicable channels. The channels that failed are also reported by Zero Fail bits in the Channel Descriptors, Status Codes 57, 77, and 97. Bit is cleared upon successful completion of the Zero routine.

2 6 A to D Limit Correctable error / Fatal error

Sense: 1 = Fail. The output of the A to D converter is continuously monitored during all operational modes. This bit is set if the data is equal to the minimum (0) or maximum (1024) number of counts. Failure sets the Check Status flag and the Channel Monitor bits for the applicable channels. Corrective action is to check for 1) wrong gas or concentration in sample cell, 2) occlusion or 3) hardware failure. Self-clearing if subsequent A/D conversions are within the above limits.

2 7 Pressure range fail Correctable error / Fatal error

Sense: 1 = Fail. Bit is set if the pressure transducer output is above or below an indicated pressure of 500 to 850 Torr. Failure sets the Check Status flag and the Channel Monitor bits for CO₂, N₂O and Pressure. Corrective action is to check for occlusion. May also indicate hardware failure. Self-clearing if subsequent pressure readings are within the above limits.

APPENDIX B

Zero Required:

If a Zero is required, Status Codes 30 - 33 indicate the reason. If any of the following bits are set it is considered a Correctable error and Check Status flags are set for all channels. Corrective action is to issue the Zero command. The error condition will be reset upon successful completion of the Zero routine.

3 0 Temperature drift Correctable error

Sense: 1 = Temperature drift. If Temperature Drift is indicated, the ambient temperature has changed more than ± 5 degrees C from the value recorded at the completion of the last Zero sequence. This bit sets the Check Status flag, the Zero Required bit (Status Code 05), and all Channel Monitor bits. Reset by a successful Zero routine.

3 1 Reference level shift Correctable error

Sense: 1 = Reference Level Shift. If this condition is indicated, the Reference channel IR level has changed more than $\pm 1\%$ from the value recorded at the completion of the last Zero routine. This indicates a change in transmission in the optical path; for example, due to contamination in the sample cell. This bit sets the Check Status flag, the Zero Required bit (Status Code 05), and all Channel Monitor bits. Reset by a successful Zero routine.

3 2 Zero Failed Correctable error

Sense: 1 = Zero failed. If this condition exists, one or more channels were not Zeroed during the previous Zero routine. This bit sets the Check Status flag, the Zero Required bit (Status Code 05), and all Channel Monitor bits. The offending channels are identified in the Channel Descriptor (bits 57, 77, 97, and 107). Reset by a successful Zero routine.

3 3 Initial Zero Required Correctable error

Sense: 1 = Timeout. This bit reports that a Zero routine is required because the Warmup timer has timed out. This bit sets the Check Status flag, the Zero Required bit (Status Code 05), and all Channel Monitor bits. Reset by a successful Zero routine.

3 4 Output Filtering On/Off Informative

Sense: 1 = Filtering off. Indicates that the default filtering characteristics are not in effect. The 4620 normally averages the previous x readings before transmitting a data point. The filtering characteristics can be modified with the \$12 command.

4 0 Continuous readings on/off Informative

Sense: 1 = Continuous. Indicates whether single set or continuous output mode of transmitting channel data is selected.

4 1 O2 Digital / Analog Informative

Sense: 1 = Digital. The default condition is to obtain O2 information from an analog O2 sensor. This bit indicates that O2 data was transmitted to the 4620 digitally with the \$11 command and that the 4620 is using this data for interference corrections.

4 2 O2 /Reference output Correctable error

Sense: 1 = Reference. Indicates status of O2/reference channel. Command \$D4 toggles the channel and switches the output Reference data for troubleshooting. Reference is assumed to be a correctable error condition and sets the Check Status flag in the O2 channel. Corrective action is to reset channel to O2 with \$D4 command.

4 3 CO2 In Percent / Torr Informative

Sense: 1 = Torr. Indicates that CO2 concentration is being reported in units of Torr. Default is units of percent.

4 4 Solenoid 1 Informative

Sense: 1 = on. Indicates state of pneumatics Solenoid 1 TTL output line. Solenoid 1 is used to select Patient / Room air gas to sample cell.

4 5 Solenoid 2 Informative

Sense: 1 = on. Indicates state of pneumatics Solenoid 2 TTL output line. Solenoid 2 is not presently used by the 4620.

4 6 Pump State Informative

2 bits. Indicates state of the Pump TTL output lines. The sense is the same as the output lines:

flow rate purge	00
flow rate purge	01
flow rate purge	10
pump off	11

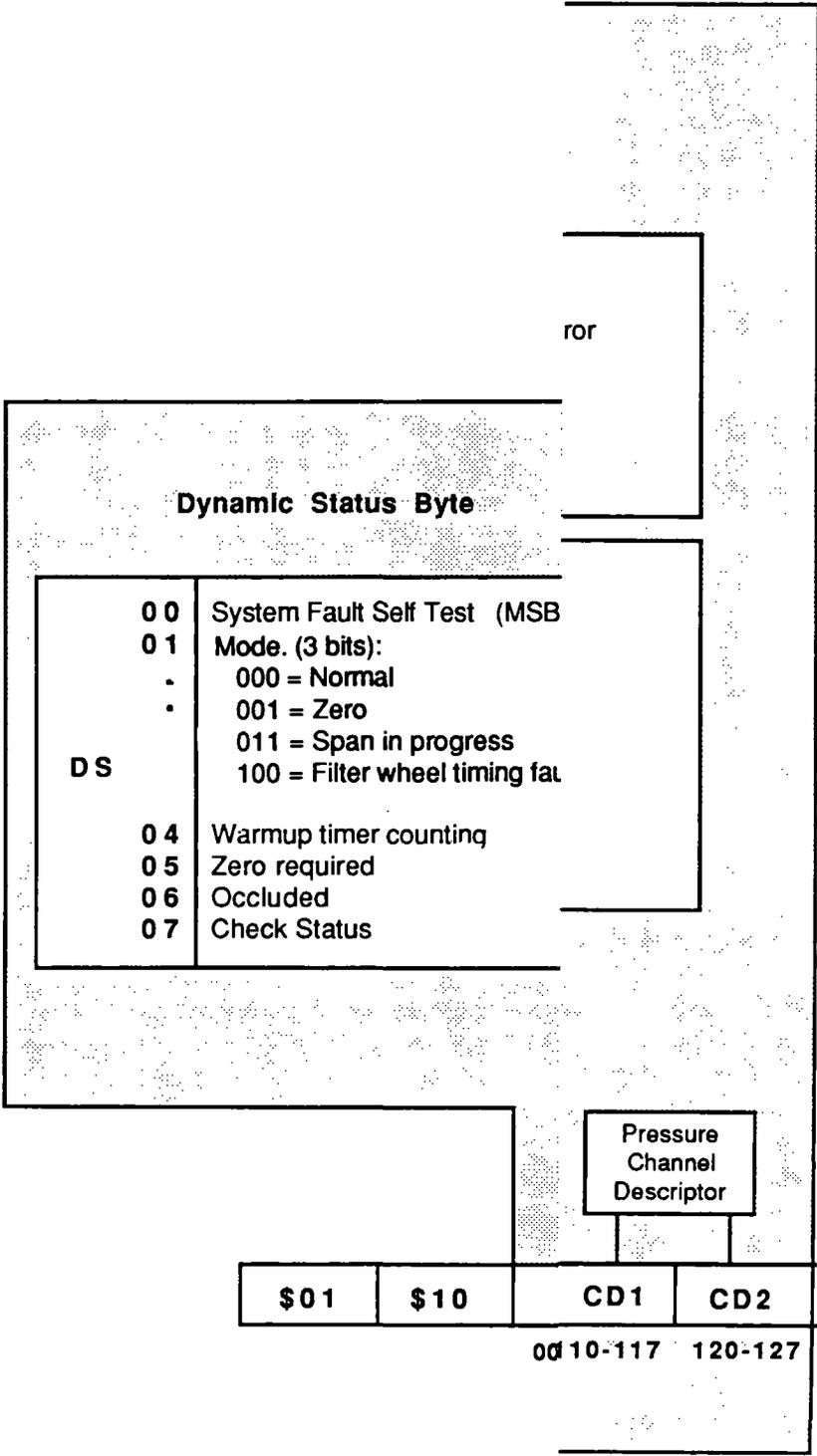
APPENDIX B

Channel Descriptor bytes.

Note: Status codes 51 - 127 are located in the Channel Descriptor bytes.

- | | | |
|--|--|--------------------------|
| 5 1 | AGC Error | Fatal error |
| Indicates an internal problem with the reference channel. Sets the Check Status flag and the Channel Monitor bits for the CO ₂ and N ₂ O channels. | | |
| 5 2 | Channel Data Processing Error | Fatal error |
| Indicates a problem with math overflow or a bad NOVRAM table. Sets the Check Status flag and the Channel Monitor bits for the applicable channels. | | |
| 5 3 | A to D Error | Fatal error |
| Indicates a reading out of range. Sets the Check Status flag and the Channel Monitor bits for the CO ₂ and N ₂ O channels. | | |
| 54, 74, 94, 114 | Span Fail | Correctable error |
| Sense: 1 = Fail. These are channel descriptor bits. Bit is set in the appropriate channel if the 4620 is unable to complete the Span process due to $\pm 15\%$ requirement. See Status Code 24 (Span Fail). Sets the Check Status flag and the Channel Monitor bits for | | |
| 55, 75, 95, 115 | Compensation pressure Invalid | Correctable error |
| Sense: 1 = Fail. These are channel descriptor bits. Set in the appropriate channel if 4620 cannot properly compensate for pressure during channel data processing. See Status Code 27 (Pressure Range Fail). Sets the Check Status flag and the Channel Monitor bits for Corrective action is to check for occlusion. | | |
| 7 6 | Compensation O₂ Invalid | Correctable error |
| Sense: 1 = Fail. Set if 4620 cannot properly compensate the CO ₂ channel for Oxygen interference. This error can appear only in the CO ₂ channel. Bit may be set due to an A to D failure or span failure in the O ₂ channel. Sets the Check Status flag and the Channel Monitor bit for CO ₂ . Corrective action is to examine contents of the sample cell, or check for a Span failure in the O ₂ channel | | |
| 57, 77, 97 | Zero Fail | Fatal error |
| Sense: 1 = Fail. These are channel descriptor bits. Bit is set in the appropriate channel if the 4620 is unable to complete the Zero process. See Status Code 25 (Zero Fail). | | |
| 8 1 | Compensation N₂O Invalid | Correctable error |
| Sense: 1 = Fail. Set if 4620 cannot properly compensate the CO ₂ channel for N ₂ O interference. This error can appear only in the CO ₂ channel. Sets the Check Status flag and the Channel Monitor bit for CO ₂ . Corrective action is to examine contents of the sample cell, or check for Span failure in the N ₂ O channel. | | |

The following drawings are included for reference only and may not reflect the most current version available. They are not intended for design or procurement purposes. Please contact Andros for current documentation.



Dynamic Status Byte

00	System Fault Self Test (MSB
01	Mode. (3 bits):
-	000 = Normal
.	001 = Zero
	011 = Span in progress
	100 = Filter wheel timing fat
DS	
04	Warmup timer counting
05	Zero required
06	Occluded
07	Check Status

Pressure Channel Descriptor

\$01	\$10	CD1	CD2	CS
------	------	-----	-----	----

0d 10-117 120-127

← Status word

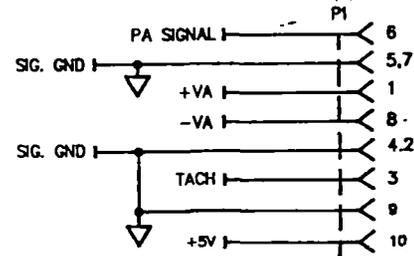
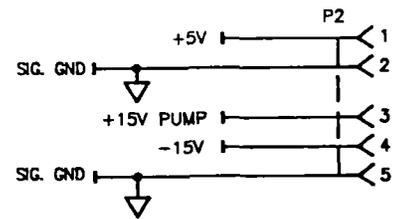
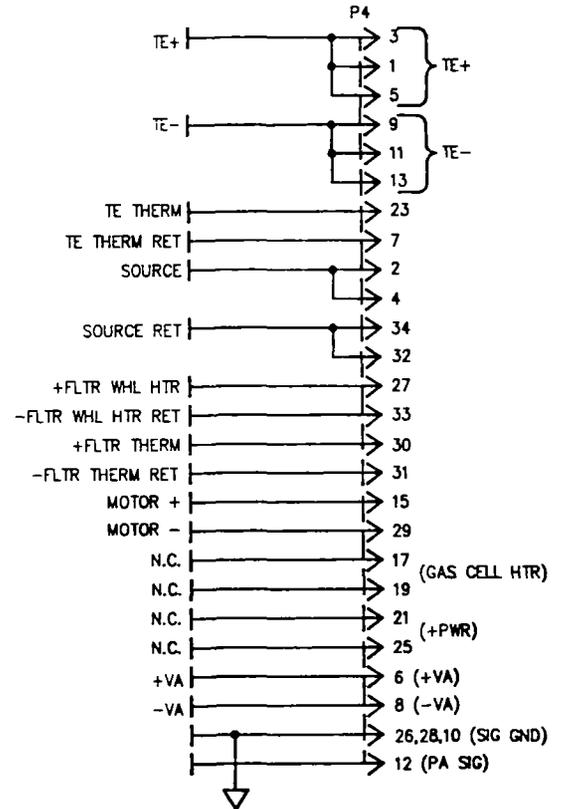
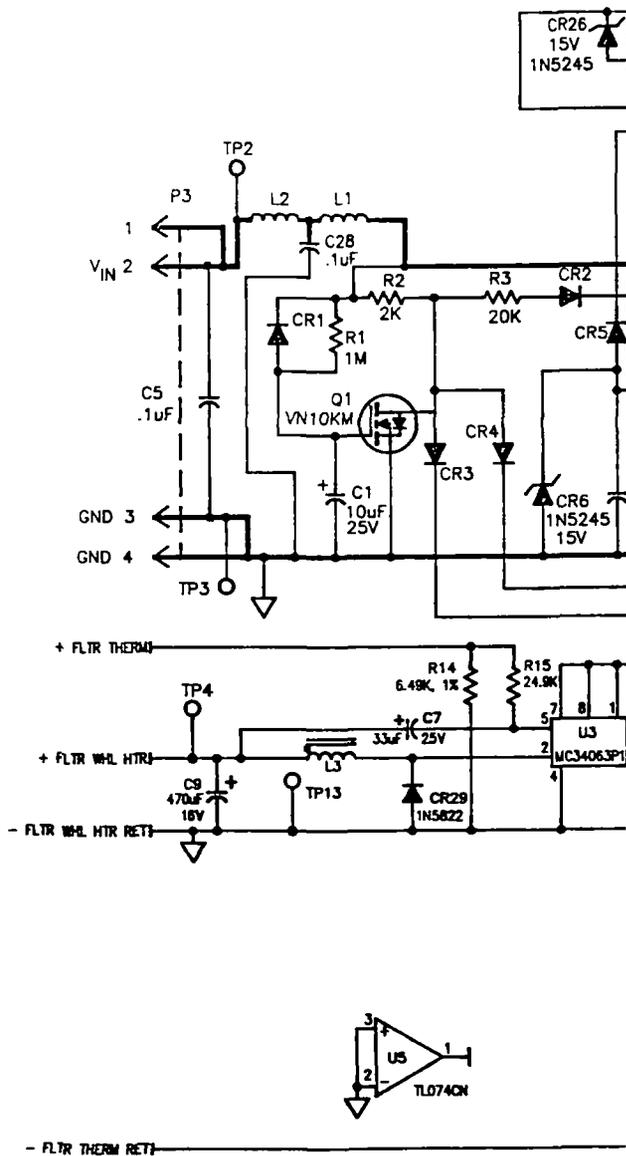
← Status codes



PROPRIETARY DATA

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ANDROS ANALYZERS INCORPORATED

REVISION	DESCRIPTION	ENGINEER	DATE
8		W. H. STEIN	1/11/89
3		S. W. WILSON	1/11/89
19		W. H. STEIN	1/11/89
5			

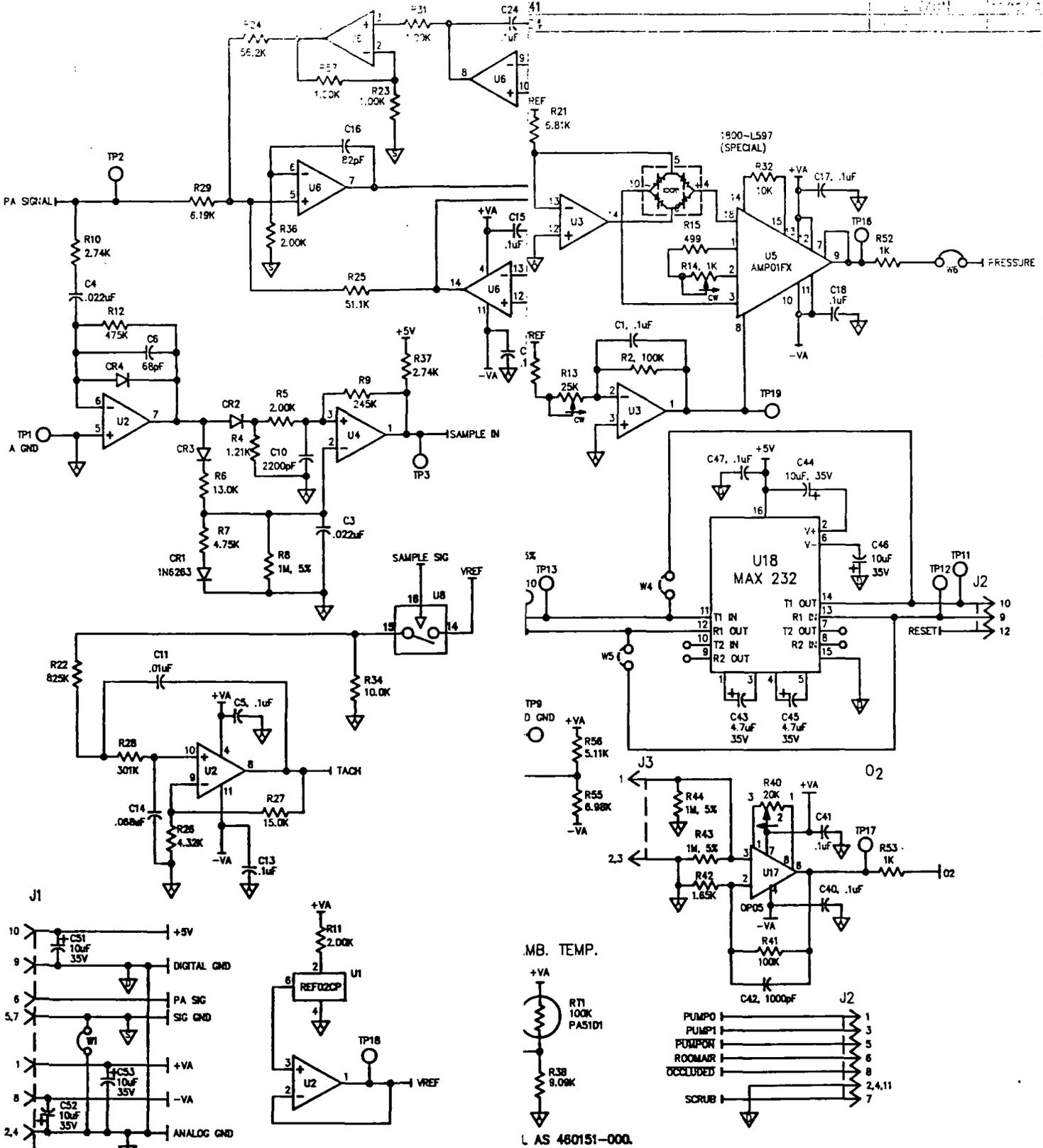


- NOTES: UNLESS OTHERWISE SPECIFIED
1. ALL RESISTOR ARE 1/4W, 5% CARBON.
 2. ALL DIODES ARE 1N4148.
 3. **---** = HI CURRENT PATH

DESIGNATORS		
TYPE	LAST USED	NOT USED
RES	R1	
RES	R2	
RES	R3	
RES	R4	
RES	R5	
RES	R6	
RES	R7	
RES	R8	
RES	R9	
RES	R10	
RES	R11	
RES	R12	
RES	R13	
RES	R14	
RES	R15	
RES	R16	
RES	R17	
RES	R18	
RES	R19	
RES	R20	
RES	R21	
RES	R22	
RES	R23	
RES	R24	
RES	R25	
RES	R26	
RES	R27	
RES	R28	
RES	R29	
RES	R30	
RES	R31	
RES	R32	
RES	R33	
RES	R34	
RES	R35	
RES	R36	
RES	R37	
RES	R38	
RES	R39	
RES	R40	
RES	R41	
RES	R42	
RES	R43	
RES	R44	
RES	R45	
RES	R46	
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RES	R54	
RES	R55	
RES	R56	
RES	R57	
RES	R58	
RES	R59	
RES	R60	
RES	R61	
RES	R62	
RES	R63	
RES	R64	
RES	R65	
RES	R66	
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REVISION HISTORY	DESCRIPTION	DATE	BY



- NOTES:**
- U3 AND U8 ARE TL074A.
 - U4 IS LM383.
 - U8 IS DG212.
 - DIODES ARE 1N4148, EXCEPT WHEN NOTED.
 - RESISTORS ARE 1/8W, 1%, EXCEPT WHEN NOTED.
 - U2 IS 34074.

DESIGNATORS		
TYPE	LAST USED	NOT USED
U1	U1	C12, C21, C22, C48, C49, C51
U2	U2	
U3	U3	
U4	U4	
U5	U5	
U6	U6	
U7	U7	
U8	U8	
U9	U9	
U10	U10	
U11	U11	
U12	U12	
U13	U13	
U14	U14	
U15	U15	
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U40	U40	
U41	U41	
U42	U42	
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U44	U44	
U45	U45	
U46	U46	
U47	U47	
U48	U48	
U49	U49	
U50	U50	

ANDROS ANALYZERS INCORPORATED
BERKELEY, CA

**SCHEMATIC, PCB,
MDL 4620**

FORMAT	DRAWING #	REVISION
D	770151-000	D
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