

INSTRUCTION MANUAL

MODEL 360U

HIGH SENSITIVITY

CARBON DIOXIDE ANALYZER

TELEDYNE / API VERSION

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SAFETY MESSAGES

Your safety and the safety of others is very important. We have provided many important safety messages in this manual. Please read these messages carefully.

A safety message alerts you to potential hazards that could hurt you or others. Each safety message is associated with a safety alert symbol. These symbols are found in the manual and inside the instrument. The definition of these symbols is described below:



GENERAL WARNING/CAUTION: Refer to the instructions for details on the specific danger.



CAUTION: Hot Surface Warning



CAUTION: Electrical Shock Hazard



Technician Symbol: All operations marked with this symbol are to be performed by qualified maintenance personnel only.

CAUTION

THE ANALYZER SHOULD ONLY BE USED FOR THE PURPOSE AND IN THE MANNER DESCRIBED IN THIS MANUAL.

IF YOU USE THE ANALYZER IN A MANNER OTHER THAN THAT FOR WHICH IT WAS INTENDED, UNPREDICTABLE BEHAVIOR COULD ENSUE WITH POSSIBLY HAZARDOUS CONSEQUENCES.



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1.0 INTRODUCTION

1.1 Preface

Teledyne API is pleased that you have purchased the Model 360U. We at Teledyne API will be pleased to provide you with any support required so that you may utilize our equipment to the fullest extent.

The Teledyne API Model 360U keyboard/operator interface makes the Teledyne API a very user-friendly system. We hope you will not experience any problems with the Model 360U but if you do, the built-in tests and diagnostics should allow you to quickly and easily find the problem. In addition, our customer service department is always available to answer your questions.

1.2 Warranty

ADVANCED POLLUTION INSTRUMENTATION, INC.

02024c

Prior to shipment, Teledyne API equipment is thoroughly inspected and tested. Should equipment failure occur, Teledyne API assures its customers that prompt service and support will be available.

COVERAGE

After the warranty period and throughout the equipment lifetime, Teledyne API stands ready to provide on-site or in-plant service at reasonable rates similar to those of other manufacturers in the industry. All maintenance and the first level of field troubleshooting are to be performed by the customer.

NON-TELEDYNE API MANUFACTURED EQUIPMENT

Equipment provided but not manufactured by Teledyne API is warranted and will be repaired to the extent and according to the current terms and conditions of the respective equipment manufacturers warranty.

GENERAL

Teledyne API warrants each Product manufactured by Teledyne API to be free from defects in material and workmanship under normal use and service for a period of one year from the date of delivery. All replacement parts and repairs are warranted for 90 days after the purchase.

If a Product fails to conform to its specifications within the warranty period, Teledyne API shall correct such defect by, in Teledyne API's discretion, repairing or replacing such defective Product or refunding the purchase price of such Product.

The warranties set forth in this section shall be of no force or effect with respect to any Product:

(i) that has been altered or subjected to misuse, negligence or accident, or (ii) that has been used in any manner other than in accordance with the instruction provided by Teledyne API or (iii) not properly maintained.

THE WARRANTIES SET FORTH IN THIS SECTION AND THE REMEDIES THEREFORE ARE EXCLUSIVE AND IN LIEU OF ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR PARTICULAR PURPOSE OR OTHER WARRANTY OF QUALITY, WHETHER EXPRESSED OR IMPLIED. THE REMEDIES SET FORTH IN THIS SECTION ARE THE EXCLUSIVE REMEDIES FOR BREACH OF ANY WARRANTY CONTAINED HEREIN. TELEDYNE API SHALL NOT BE LIABLE FOR ANY INCIDENTAL OR CONSEQUENTIAL DAMAGES ARISING OUT OF OR RELATED TO THIS AGREEMENT OF TELEDYNE API'S PERFORMANCE HEREUNDER, WHETHER FOR BREACH OF WARRANTY OR OTHERWISE.

TERMS AND CONDITIONS

All units or components returned to Teledyne API should be properly packed for handling and returned freight prepaid to the nearest designated Service Center. After the repair, the equipment will be returned, freight prepaid.

1.3 Principle of Operation

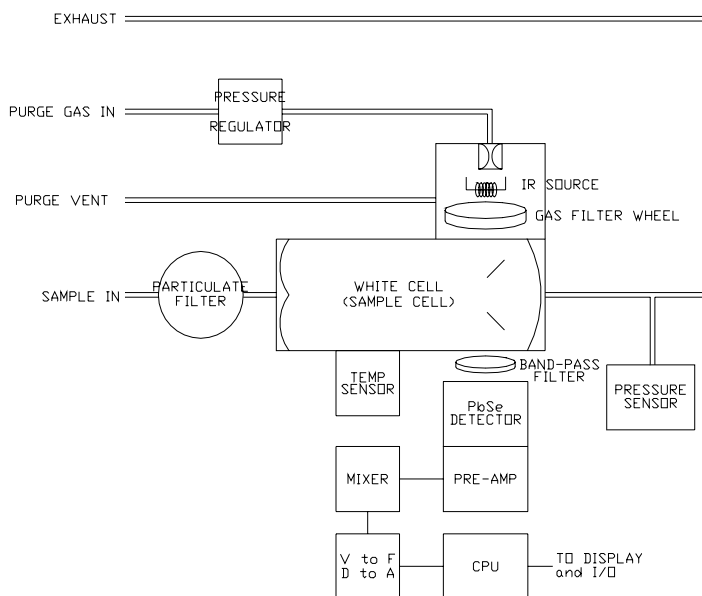
The detection and measurement of carbon dioxide in the Model 360U is based on the absorption of infrared (IR) radiation by CO₂ molecules at wavelengths near 4.2 microns. In practice, the Model 360U uses a high-energy heated element to generate broadband IR light. This light is passed through a rotating Gas Filter Wheel that causes the beam to alternately pass through a gas cell filled with Nitrogen, (the Measure Cell) and a cell filled with CO₂/Nitrogen Mixture (the Reference Cell). This alternation occurs at a rate of 30 cycles/second and causes the beam to be modulated into Reference and Measure pulses. During a Reference pulse, the CO₂ in the gas filter wheel effectively strips the beam of all IR energy at wavelengths where CO₂ can absorb. This results in a beam which is unaffected by any CO₂ in the Sample Cell. During the Measure pulse, the Nitrogen in the filter wheel does not affect the beam which can subsequently be absorbed by any CO₂ in the sample cell. The Gas Filter wheel also incorporates an optical chopping mask that superimposes a 90 Cycles/Second Light/Dark modulation on the IR Beam. This high frequency modulation is used to maximize detector signal-to-noise performance.

After the gas filter wheel, the IR beam enters the folded multi-pass sample cell that is used to achieve maximum sensitivity. The beam then passes through a band-pass interference filter to limit the light to wavelength of interest. Finally, the beam strikes the detector which is a thermoelectrically cooled solid-state photo-conductor.

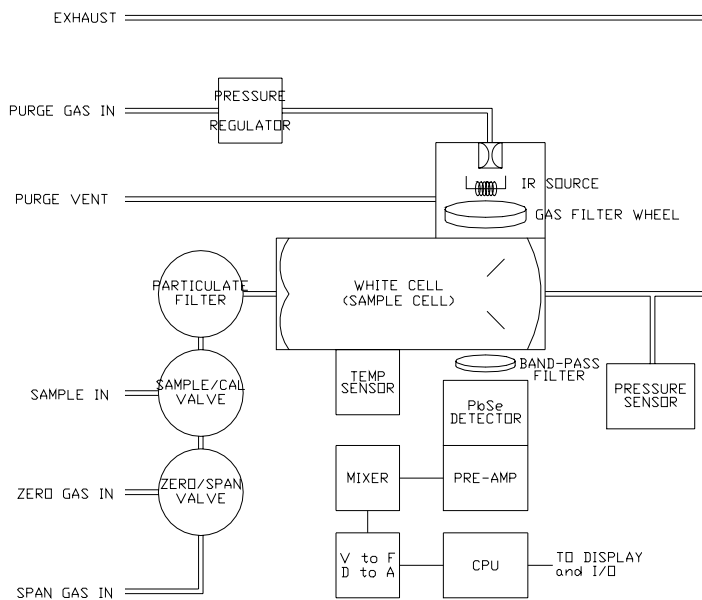
This detector, along with its pre-amplifier and bias voltage supply convert the light signal into a modulated voltage signal.

The detector output is electronically demodulated to generate two DC voltages, CO₂_MEAS and CO₂_REF. These voltages are proportional to the light intensity striking the detector during the Measure pulse and Reference pulse, respectively.

BASIC ANALYZER



ANALYZER WITH ZERO/SPAN VALVES



FLOW DIAGRAM

FIGURE 1.1

1.4 Specifications

Ranges	User selectable to any full-scale range from 0 - 100 ppb up to 100 ppm
Zero Noise	< 2.5 ppb (rms)
Span Noise	< 0.5% of reading (rms) ②
Lower Detectable Limit	< 5 ppb
Zero Drift (24 hours)	<10 ppb ①
Zero Drift (7 days)	<20 ppb ①
Span Drift (7 days)	1% of reading ①②
Linearity	1.0% of full scale
Precision	0.5% of reading
Lag Time	10 sec
Rise/Fall Time (95%)	<90 sec
Purge Flow Rate	1000cc/min. \pm 20%
Temperature Range	15-35°C
Humidity Range	0-95%RH, non-condensing
Temp Coefficient	< 5 ppb or 0.05 % of reading per °C
Voltage Coefficient	< 5 ppb or 0.05 % of reading per V
Dimensions HxWxD	7"x 17"x 25" (178mm x 432mm x 635mm)
Weight	50 lbs (22.7 kg)
Power	115V/60Hz, 220V/50Hz, 220V/50Hz 250 Watts
Power, CE	230V/50Hz, 2.5A
Recorder Outputs	\pm 100 mV, \pm 1 V, \pm 5 V, \pm 10 V, 0-20mA, 4-20mA
Status Output	10 status outputs from opto-isolators
Alarm output	2 alarm outputs from opto-isolators

① at constant temperature and voltage

② or the limit at zero, whichever is greater

1.5 Installation and overview

The Model 360U is shipped with the following standard equipment:

1. Power cord.
2. Instruction manual.

CAUTION

TO AVOID PERSONAL INJURY, ALWAYS USE TWO PERSONS TO LIFT AND CARRY THE MODEL 360.



Upon receiving the Model 360U please do the following:

1. Verify no apparent shipping damage. (If damage has occurred please advise shipper first, then **Teledyne API**.)
2. When installing the Model 360U, allow a minimum of 4 inches (100mm) of clearance at the back of the instrument and 1 inch (25mm) of clearance on each side for proper ventilation. Also, be sure that the clearance below the chassis is unobstructed by at least the height of the instrument feet.
3. Connect sample inlet line to the sample port on rear panel.
4. Connect a source of CO₂-free gas at 30 psig to the purge gas port on the rear panel.

NOTE

SEE FIGURE 1.3 FOR REAR PANEL PNEUMATIC CONNECTIONS. SAMPLE GAS SHOULD ONLY COME INTO CONTACT WITH PTFE, GLASS OR STAINLESS STEEL. LEAK CHECK ALL FITTINGS WITH SOAP SOLUTION.

MAXIMUM PRESSURE FOR LEAK CHECK IS 5 PSI.

CAUTION

CONNECT THE EXHAUST FITTING ON THE REAR PANEL (SEE FIG. 1.4) TO A SUITABLE VENT OUTSIDE THE ANALYZER AREA.



5. Connect a recording device to the terminal strip connections on the rear panel (See Figure 1.3).
6. Connect the power cord to an appropriate power outlet (see the serial number tag for correct voltage and frequency).

CAUTION

CHECK THAT ANALYZER IS SET UP FOR PROPER VOLTAGE AND FREQUENCY.



CAUTION

POWER PLUG MUST HAVE GROUND LUG.



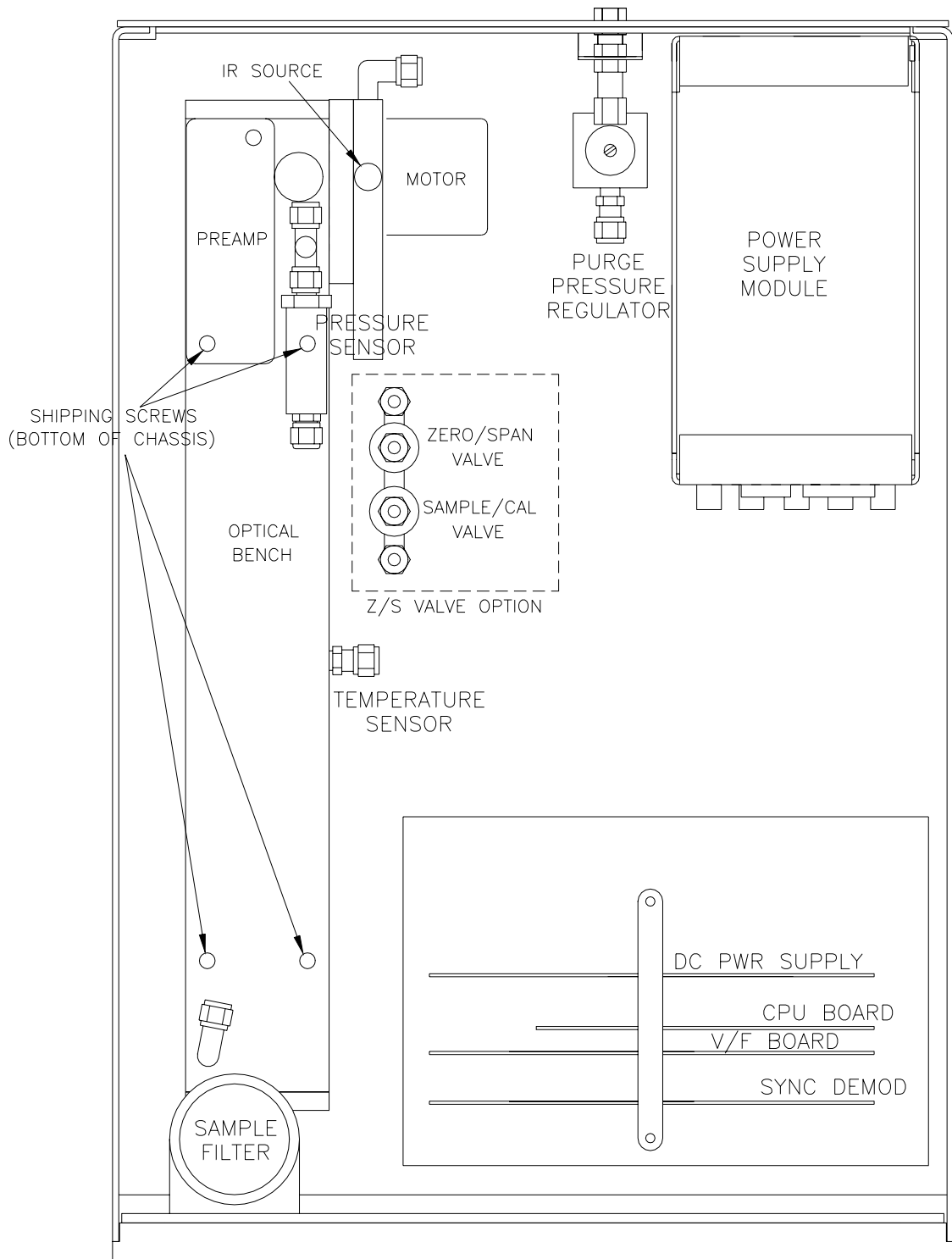
7. Turn on the M360U by switching the switch on the lower right corner of the front panel (See Figure 2.1). The front panel display should light with a sequence of messages, -API - M360U - software version number, then a normal display as shown in Figure 2.2.
8. Allow about 60 minutes for the temperatures to come up to their respective set-points, then press the left most button on the front keyboard to scroll through the TEST values. Compare these values to those noted during the final factory checkout listed in Table 1.1. The values observed should closely match the Table 1.1 values.
9. Select the range on which the analyzer will be calibrated.

- a. From the SAMPLE menu press **SETUP** to enter the SETUP menu. (See Figure 2.2 for appearance of front panel.)
 - b. Enter the PASSWORD (818).
 - c. Press **RNGE** (RANGE).
 - d. Press **SET**.
 - e. Enter the derived full scale range for analog outputs and press **ENTR**.
 - f. Press EXIT 2 times to return to the SAMPLE menu.
10. Adjust the analyzer zero point.
- a. Input zero air into the sample port.
 - b. Press **CAL** from the SAMPLE menu and enter the password (**818**).
 - c. Press **ZERO**.
 - d. It usually takes about 5 to 10 minutes for the reading to stabilize near zero. After a stable reading has been obtained press **ENTR**. The display should now read 0.0 ppm carbon dioxide.

NOTE

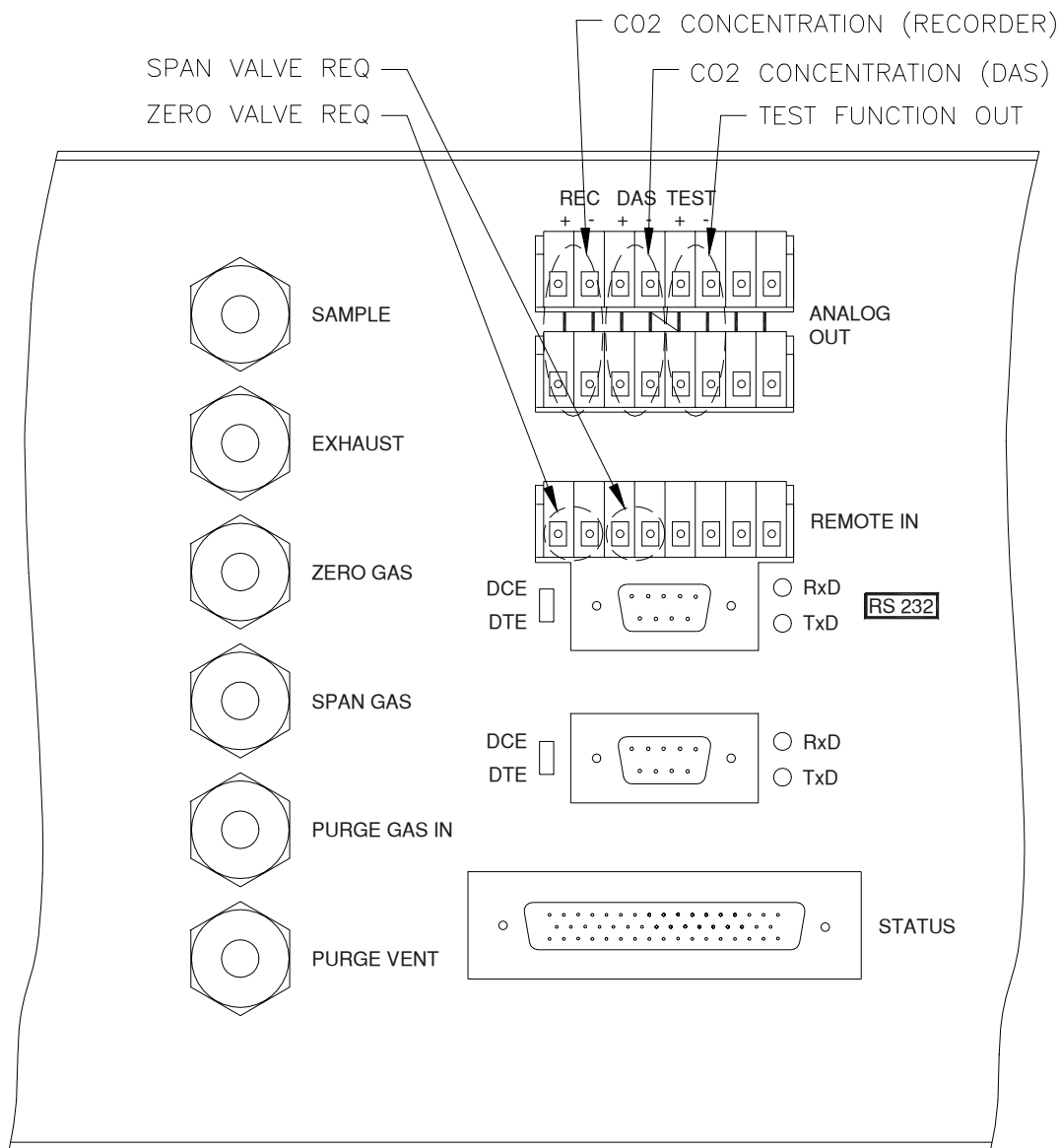
REPEATEDLY PRESSING ENTR TO GET THE INSTRUMENT TO DISPLAY THE CORRECT SPAN/ZERO VALVE DOES NOT IMPROVE THE ACCURACY OF THE CALIBRATION, NOR DOES IT SPEED UP STABILIZATION. THE REASON FOR WAITING 5-10 MINUTES IS THAT IT TAKES THE INSTRUMENT A PERIOD OF TIME TO ESTABLISH AN ACCURATE AVERAGE FOR THE SPAN/ZERO READING.

11. Adjust the analyzer span point.
- a. Input span gas of approximately 80% of the related full scale range concentration from a known source through the sample port of the analyzer.
 - b. Go to manual calibration by pressing the **CAL** button while in the sample mode.
 - c. Enter the operator password (512).
 - d. The menu should now show **SPAN**, **CONC**, and **EXIT**. Enter the concentration of the CO₂ calibration gas by pressing **CONC** and entering the value from the keyboard.
 - e. Wait 10 minutes for a stable reading to be attained and then press **SPAN**, followed by **ENTR**. If the **SPAN** button is not displayed, this means that the analyzer is too far out of adjustment to do a reliable calibration and thus it is not permitted (see Section 3.1 for information on the calibration limits). The operator can exit the manual calibration procedure only by pressing the **EXIT** button.



CARBON DIOXIDE ANALYZER

FIGURE 1.2



REAR PANEL ELECTRICAL CONNECTIONS

FIGURE 1.3

1.6 Electrical and pneumatic connections

1.6.1 Electrical connections

Output #1A CO₂ concentration to Chart Recorder (REC)
Output #2A CO₂ concentration to analog Data Acquisition System (DAS)
Output #3A Test function analog output
Output #4A Not Used

Output #1B CO₂ concentration to Chart Recorder (REC)
Output #2B CO₂ concentration to analog Data Acquisition System (DAS)
Output #3B Test function analog output
Output #4B Not Used

Input #5 Zero valve request
Input #6 Span valve request
Input #7 Not Used
Input #8 Not Used

There are 3 eight-pin connector strips on the rear panel shown in Figure 1.3. The pins are divided into 4-plus/minus pairs and have the functions shown above.

Outputs A and B have identical signals and electrical characteristics. Outputs 1 and 2 provide the CO₂ concentration as an Analog signal and can be configured as described in Section 9.4. Output 3 has analog TEST function signals routed to it. See Diagnostics in Section 5 for details.

1.6.2 Remote contact closures zero/span inputs and status outputs

Remote contact closures can be used to remotely energize the zero/span valves to do a zero or span check. The external contact closure should be capable of switching 12 VDC at 50 ma.

Refer to Figure 1.3 for connection location. See Sections 1.8.6 and 3.6 for further details.

NOTE

ZERO OR SPAN CHECKS CAN BE PERFORMED IN ANY ORDER.

1.6.3 Status Outputs

Status outputs report analyzer conditions via contact closures located on the DB-50 connector on the rear panel. The contacts are NPN transistors that can pass 50 mA of DC current. The pin assignments are listed in Table 1.1.

STATUS OUTPUTS

OUTPUT #	PIN PAIR (LOW, HIGH)	STATUS	CONDITION
1	1,2	ZERO CAL MODE	Closed circuit during Zero Calibration.
2	3,4	SPAN CAL MODE	Closed circuit during Span Calibration.
3	5,6	RESERVED	
4	7,8	TEMP ALARM	Closed circuit if any temp warning exists
5	9, 10	DIAG MODE	Closed circuit if in diagnostic mode
6	11,12	POWER ON	Closed circuit if main power is on
7	13,14	PRESS ALARM	Closed circuit if low pressure
8	15,16	HIGH RANGE SELECTED	Closed circuit if the auto-range function has switched the analyzer into high range.
9	17,18	SYSTEM OK	Closed circuit if no warning conditions exist
10	19,20	SOURCE WARNING	Closed circuit if the analyzer source intensity is out of limits.
11	21,22	ALM1	Closed circuit if gas concentration is exceeding the ALM1 set limit.
12	23,24	ALM2	Closed circuit if gas concentration is exceeding the ALM2 set limit.

TABLE 1.1

1.6.4 RS-232

The RS-232 connection is a male, 9-pin D-sub connector at the location shown in Figure 1.3.

1.6.5 Pneumatic system

Sample enters the analyzer through a particulate filter element (47 mm diameter) mounted immediately behind the front panel. The sample then enters directly into the sample cell. Please see Figure 1.1 for a flow diagram and Figure 1.4 for pneumatic connections.

NOTE

THIS INSTRUMENT IS A GAS ANALYZER. CARE MUST BE TAKEN TO INSURE THAT ONLY A CLEAN, DRY SAMPLE IS INTRODUCED INTO IT. WATER OR CONDENSING WATER VAPOR WILL CAUSE EXTENSIVE DAMAGE TO THE ANALYZER. IF YOU HAVE OR POTENTIALLY HAVE CONDENSING WATER VAPOR OR PARTICULATE IN YOUR SAMPLE, PLEASE PROPERLY CONDITION THE SAMPLE PRIOR TO INTRODUCING IT INTO THE ANALYZER. TELEDYNE API IS NOT LIABLE FOR ANALYZER DAMAGE CAUSED BY WATER.

1.6.6 Sample gas connection

A section of 1/4" O.D. PTFE tubing up to 3 meters in length is needed to connect the sample source to the analyzer (see Figure 1.4).

NOTE

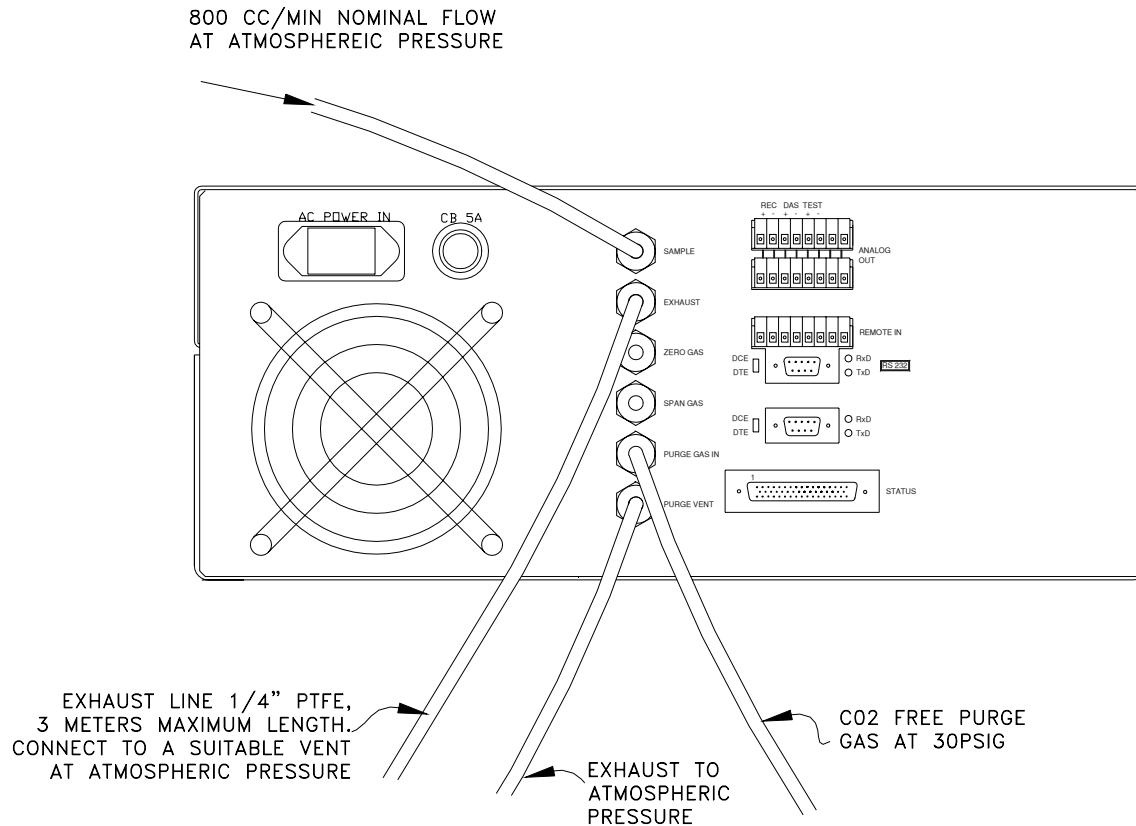
USE PTFE, GLASS, STAINLESS STEEL OR NON-REACTIVE MATERIALS FOR SAMPLE GAS CONNECTIONS.

1.6.7 Exhaust connections

A single 1/4" O.D. tube should be connected from the analyzer sample exhaust to a suitable vent. The maximum length of the exhaust line should not exceed 3 meters (see Figure 1.4).

CAUTION

CONNECT THE EXHAUST FITTING ON THE REAR PANEL (SEE FIG. 1.4) TO A SUITABLE VENT OUTSIDE THE ANALYZER AREA AND AWAY FROM PERSONNEL.



REAR PANEL PNEUMATIC CONNECTIONS

FIGURE 1.4

1.6.8 Zero/span valve connections

Zero air and span gas manifolds should supply their respective gases at the 800cc/min nominal demand of the analyzer, at atmospheric pressure.

1.6.9 Purge gas connections

To avoid being effected by changes in the ambient CO₂ concentration the Model 360U requires that the area around the IR source and filter wheel be purged with CO₂ free gas.

A source of clean, dry gas that is free of CO₂ (such as N₂ or Instrument grade Air) should be connected to the Purge Gas port on the rear panel (see Figure 1.4). Purge gas should be supplied at a pressure of 30 psig \pm 25%, and is used at rate of approximately 1000 cc/min.

1.7 Operation verification

The Model 360U Analyzer is now ready for operation.

1. Read Sections 1.3 and all of Section 4 of the manual to understand the analyzer operation.
2. Turn on the power by pressing the on/off switch on the front panel (see Figure 2.1). The display should turn on and green (sample) status LED should be energized. The green LED should blink indicating the instrument has entered the HOLD-OFF mode. Sample mode can be entered immediately by pressing the **EXIT** button on the front panel. The red "fault" light will also be on until the temperatures and voltages are within operating limits. Clear the fault messages.
3. After a 60-minute warm-up, review the TEST function values in the front panel display by pushing the left most keyboard button labeled TEST. Not every TEST function is a diagnostic of correct analyzer operation, therefore TEST functions not covered below can be ignored for now.
4. CO2 REF, CO2 MEAS - TEST function values should be between 2000 mV and 4700 mV.
5. Pressure - 29 to 30 Inches-Mercury-Absolute at sea level. Other values will be displayed depending on altitude of analyzer.
6. Sample Temp - Ambient temperature (15 - 35°C) \pm 10 °C
7. Optical Bench Temp - 45°C \pm 1° The computer drives the temp to this setpoint.
8. Filter Wheel Temp - 68°C \pm 2° The computer drives the temp to this setpoint.
9. Box Temp - Ambient +10 °C
10. DC Power Supply - 2500 mV \pm 200 mV - This is a composite of all of the DC voltages in the instrument. The value is not important but it should be within the range indicated.
11. If the TEST functions are within the limits given above, the instrument should function correctly. If there is a problem, please read the manual and check your setup and test values. The Model 360U is now ready for calibration (see Section 3.5).

FINAL TEST AND CALIBRATION VALUES

TEST Values	Observed Value	Units	Nominal Range
CO2 MEAS		mV	2000-4700
CO2 REF		mV	1000-3700
MR RATIO			2.0-2.8
SAMPLE PRESS		in-Hg	27 - 30
BENCH TEMP		°C	48 ±2
DC POWER SUPPLY		mV	2500 ±200
SAMPLE TEMP		°C	45-50
BOX TEMP		°C	8-50
WHEEL TEMP		°C	68 ±2
Span and CAL Values			
CO2 Span Conc		PPB	700 - 900
CO2 Slope			1.0 ± .5
CO2 Offset			-0.5 - +0.5
Noise at Zero(rms)		PPB	0-2.5
Noise at Span(rms)		PPB	.5% of reading
Factory Installed Options			Option Installed
Power Voltage/Frequency			
Rack Mount, w/ Slides			
Internal Zero Span Valves			
Analog Voltage Range			0- _____ V
PROM Rev #		Serial #	
Date		Technician	

TABLE 1.2

1.8 Options

1.8.1 Rack mount with slides

This option, including slides and rack mounting ears, permits the analyzer to be mounted in a standard 19" wide x 30" deep RETMA rack.

NOTE

A 1¾" MINIMUM SEPARATION BETWEEN EACH INSTRUMENT MUST BE MAINTAINED TO ALLOW FOR AIR CIRCULATION. BLOCKING THE AIR INLET VENT ON THE BOTTOM OF THE ANALYZER WILL RESULT IN INTERNAL OVERHEATING.

1.8.2 Zero/span valves

The Zero/Span Valve option consists of two stainless steel solenoid valves mounted inside the analyzer connected to admit sample gas or customer-generated zero air or span gas.

The valves are controlled from the front panel push-buttons, the auto-timer via the RS-232 interface, or by remote contact closure.

A Zero air manifold should supply gas from a source that delivers gas at a nominal flow rate of 800 cc/min and at atmospheric pressure. The zero manifold should be connected at the Zero Air fitting on the rear of the analyzer.

A Span gas manifold should supply gas from a source that delivers gas at a nominal flow rate of 800 cc/min and at atmospheric pressure. The span gas manifold should be connected at the Span port at the analyzer's rear panel.

2.0 OPERATION

2.1 Key features

The important features of the Teledyne API Model 360U CO₂ Analyzer are listed below.

2.1.1 CO₂ readout

The Teledyne API Model 360U CO₂ Analyzer constantly displays the current Carbon dioxide reading (in PPM) in the upper right hand corner of the alphanumeric display.

2.1.2 CO₂ analog output

The Teledyne API CO₂ Analyzer provides a buffered analog output of the current CO₂ readings on each of two pairs of outputs on the rear panel (see Figure 1.3) for DAS and recorder reporting. The analog outputs provide for 20% overrange. For example, on the 500 ppm range the M360U will correctly report concentrations up to 600 ppm and output up to 6.00 volts to the DAS and recorder outputs.

In addition TEST function values can be routed to a third analog output.

2.1.3 E²ROM backup of software configuration

The Teledyne API CO₂ Analyzer has a few jumpers that need to be set by the operator. Configuration of the analyzer is done under software control and the configuration options are stored in electrically erasable (E²) ROM. Thus, configuration options are saved even when the analyzer is powered off.

There is one exception to this. The analog output voltage ranges are set by jumpers on the A/D-I/O board as shown in Section 10.6.3.

2.1.4 Adaptive filter

The Teledyne API CO₂ Analyzer is able to provide a smooth, stable output by means of an adaptive filter. During conditions of constant or nearly constant concentration the filter is allowed to grow to 720 samples (4 minutes) in length, providing a smooth, stable reading. If a rapid change in concentration is detected, the filter is cut to 60 samples to allow the analyzer to quickly respond to rapidly varying signals.

2.1.5 Data acquisition

The Teledyne API CO₂ Analyzer contains a built-in data acquisition system which keeps track of the average CO₂ readings and the last 100 averages. This data is made available to other systems via the RS-232 interface. The analyzer can be programmed to automatically output a 1 minute to 60 minute average. The last 100 averages can be called up through the remote RS-232 I/O or viewed on the display through keyboard call-up.

2.1.6 RS-232 interface

The Teledyne API CO₂ Analyzer features an RS-232 interface which can output the instantaneous and/or average CO₂ data to another computer. It can also be used as a command and status channel to allow another computer to control the analyzer. Refer to Appendix Figure A.1 for details on using the RS-232 interface. Tips on connecting the RS-232 port can be found in Appendix A.

2.1.7 Password protection

The Teledyne API CO₂ Analyzer provides password protection of the calibration and setup functions to prevent incorrect adjustments to the analyzer. There are three levels of passwords that correspond to operator, supervisor/maintenance, and analyzer configuration functions. When prompted for a password, any of the valid passwords can be entered, but the CPU will limit access to the functions allowed for that password level. Each level allows access to the functions of all the levels below plus some additional functions. Table 2.1 lists the password levels and the functions allowed for each level.

PASSWORD LEVELS

Password	Level	Functions Allowed
No password	0	TEST MSG CLR
Operator (512)	1	CALZ CALS CAL
Setup (818)	2	SETUP
Supervisor (101)	3	ALL

TABLE 2.1

NOTE

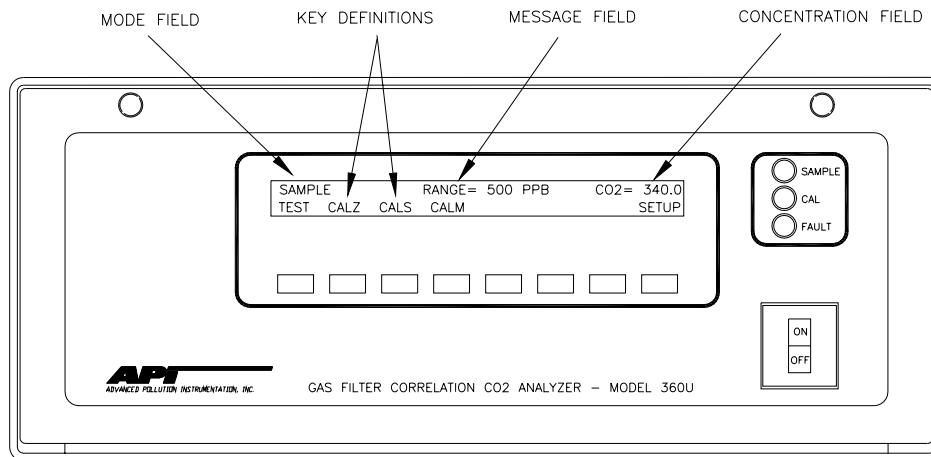
THE OPERATOR AND SETUP PASSWORDS CAN BE DISABLED. TO DO THIS, ENTER SETUP-PASSWORD AND TOGGLE "ON" TO "OFF". PUSH "ENTR" AND THE PASSWORDS WILL BE DISABLED

2.2 Front panel

This section describes the operator interface from the point of view of the front panel. The front panel consists of a 2-line by 40-character alphanumeric display, 8 push buttons, and 3 status LED's. Each of these features is described below.

2.2.1 Front panel display

The display is divided into 4 main "fields": the **mode** field in the upper left, the **message** field in the top center, the sample concentration field consisting of the most recent instantaneous carbon dioxide value field in the upper right, and the MENU field which occupies the entire bottom line of the display. A typical display is shown in Figure 2.1.



MODEL 360U FRONT PANEL

FIGURE 2.1

The mode field indicates the current mode of the analyzer. Usually, it shows "SAMPLE A", indicating that the instrument is in the sample mode and that automatic span checking is enabled. Manual span checking or calibration can only be performed by pressing the buttons on the front panel labeled "CALZ", "CALS", or "CAL". Automatic span check only occurs at the preset time. Dynamic span adjust can be performed during automatic or remote span checks. Remote span adjustment is performed via a command from the RS-232 or the external contact closure inputs. Calibration and span adjustments are discussed in greater detail in Section 3.6. Table 2.2 below lists all the possible modes in the analyzer and their meanings.

SYSTEM MODES

Mode	Meaning
SAMPLE x (1)	Sampling normally
SAMPLE x (1)	Flashing indicates adaptive filter is on
ZERO CAL x (2)	Doing a zero check or adjust
SPAN CAL x (2)	Doing a span check or adjust
MP CAL	Doing a multi-point calibration
SETUP xxx (3)	Configuring analyzer (sampling continues)
DIAG DAS (4)	Data Acquisition configuration
DIAG I/O (4)	Test digital I/O signals
DIAG AOUT (4)	Test analog output channels
DIAG D/A (4)	Configure and Calibrate Digital to Analog converters
DIAG TCHN (4)	Configure Test Channel output
(1) x = A (auto) (2) x = M (manual), A (auto), R (remote) (3) xxx = software revision (e.g. A.9) (4) diagnostic test modes	

TABLE 2.2

The message field shows test measurements or warning messages. Tables 2.3 and 2.4 summarize the test measurements and warning messages and their meanings. Refer to Sections 4.0 and 5.0 for detailed information on viewing test measurements and warning messages and clearing warnings.

TEST MEASUREMENTS

Test Message	Meaning
TIME=xx:xx:xx	Current time-of-day (HH:MM:SS)
RANGE=xxxx PPM	Analog output full-scale range
STABIL=x.xxx PPM	Standard Deviation of CO2 readings
CO2 MEAS=xxxxxx MV	Current V/F measure channel (mV)
CO2 REF=xxxxxx MV	Current V/F reference channel (mV)
MR RATIO=X.XXX	Ratio of the Reference and Measure values
PRES=xxx IN-HG-A	Absolute sample pressure - inches Hg
SAMPLE TEMP=xxx C	Temperature in the absorption cell
BENCH TMP=xxx C	Optical Bench Temperature
WHEEL TMP=xxx C	Filter Wheel Temperature
BOX TEMP=xxx C	Internal box temperature (degrees C)
DCPS=xxxxxx MV	DC power supply (mV)
SLOPE=x.xxx	Internal formula - Slope
OFFSET=xx.x MV	Internal formula - Offset

TABLE 2.3

WARNING MESSAGES

Warning Message	Meaning
SYSTEM RESET	Issued whenever analyzer is powered on
RAM INITIALIZED	RAM was erased (incl. DAS reports)
SOURCE WARNING	IR source < 2500 OR >= 5000 mV
BENCH HEAT SHUTDOWN	Optical bench temp control not working
SAMPLE PRESSURE WARN	Sample pressure < 15 or > 35 In-Hg-A
SAMPLE TEMP WARNING	Sample temperature < 10°C or > 50°C
BOX TEMP WARNING	Box temp. < 12°C or > 48°C
BENCH TEMP WARN	Optical Bench < 43°C or > 53°C
WHEEL TEMP WARN	Filter Wheel < 63°C or > 73°C
CANNOT DYN ZERO	CO ₂ offset < -1500 or > +1500 mV
CANNOT DYN SPAN	CO ₂ slope < 0.5 or > 2.0
V/F NOT INSTALLED	A/D - I/O card not installed or bad
SYNC ERROR	No modulation on detector output

TABLE 2.4

The menu field changes depending on the mode of the analyzer and the buttons that have been pressed. It indicates the current function of each of the 8 push buttons below the display. See Section 2.2.2 for information on using the push buttons.

2.2.2 Context sensitive push buttons

The 8 push buttons below the display are programmable by the CPU in that their functions change depending on the mode of the analyzer or the operations being performed. The legend above a button identifies its current function. If there is no legend above a button, it has no function and will be ignored if pressed.

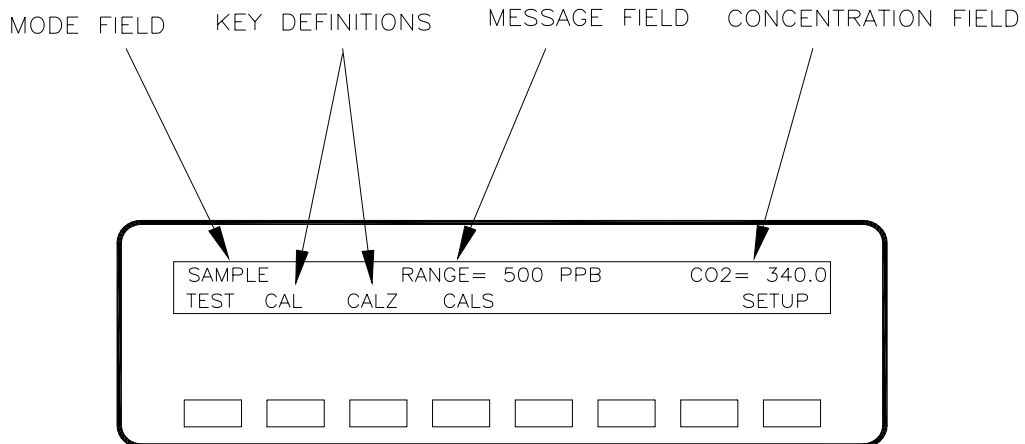


ILLUSTRATION OF NORMAL DISPLAY

FIGURE 2.2

If **TEST** is pushed, the upper center display cycles through the menu of test parameters, e.g. Sample Temp (see Table 2.3). If **CALZ** is pushed, the sequence of operations for setting the analyzer zero is initiated (see Section 3.1).

If **CALS** is pushed, the sequence of operations for setting **SPAN** is initiated (see Section 3.1).

CAL is used to initiate span setting using sample gas, such as during a formal calibration.

Pushing **MSG** will cause a message to appear on the upper center display.

Pushing **CLR** will erase a message, provided the condition causing the message has ceased.

Pushing **SETUP** changes the function of the push buttons and is used for setting basic parameters as described in Section 4.0.

2.2.3 Status LED's

The three status **LED's** to the right of the display indicate the general status of the Model 360U Analyzer. The green **SAMPLE LED** indicates the sampling status. The yellow **CAL LED** indicates the calibration status. The red **FAULT LED** indicates the fault status. Table 2.5 summarizes the meanings of the status **LED's**.

STATUS LED's

LED	State	Meaning
Green	Off	Not monitoring, DAS Disabled
	On	Monitoring normally, taking DAS data
	Blinking	Monitoring, HOLD-OFF mode on, no data to DAS (1)
Yellow	Off	Auto Cal disabled
	On	Auto Cal enabled
	Blinking	Calibrating
Red	Off	No warnings exist
	Blinking	Warnings exist
(1) This occurs during calibration holdoff, power-up holdoff and when in Diagnostic mode		

TABLE 2.5

3.0 PERFORMANCE TESTING

Zero/span checking and calibration of the Teledyne API CO₂ Analyzer is divided into two sections. Chapter 3 discusses the different methods by which the analyzer's zero and span settings may be checked and adjusted. The emphasis in Chapter 3 is on the operation of the buttons and the internal adjustments they make in the instrument.

3.1 Manual zero/span check

NOTE

ZERO OR SPAN CHECKS CAN BE PERFORMED IN ANY ORDER.

Operators can manually check the zero and span set-points of the analyzer while in sample mode by allowing the instrument to sample calibration gas and pressing the **CAL** button. This is also referred to as a multi-point calibration.

3.1.1 Zero Check

Allow the analyzer to sample zero air through the sample port. Press **CAL** button. After a few minutes the CO₂ reading should go to zero. If it doesn't, the operator may press the **ZERO** button followed by **ENTR**. This will force the CO₂ reading to go to zero and modify the internal formulas used to compute the CO₂ reading. If the **ZERO** button is not displayed, this means that the zero reading is too far out of adjustment to do a reliable calibration. The reason for this must be determined before the analyzer can be calibrated. See Section 10.5 for troubleshooting calibration problems. Pressing **EXIT** will bring you back to the Sample menu or you can leave the instrument in **CAL** mode if you are also going to make a span check.

3.1.2 Span Check

Allow the analyzer to sample span gas through the sample port. Press **CAL** button. After a few minutes the CO₂ reading should be at the expected concentration. If the correct concentration is not reached, then the instrument can be adjusted to read the correct value. To do this, press **CONC** and enter the expected concentration for calibration. The **SPAN** button should now be displayed on the front panel. Pressing **SPAN** and **ENTER** will modify the internal formulas used to compute the CO₂ reading. If the **SPAN** button is not displayed, this means that the span reading is too far out of adjustment to do a reliable calibration. The reason for this must be determined before the analyzer can be calibrated. See Section 10.5 for troubleshooting calibration problems.

3.1.3 Dual Range Calibration

If the analyzer is being operated in Dual Range mode or Auto-Ranging mode, then the High and Low ranges must be independently calibrated. When the analyzer is in Dual or Auto Range mode you will be prompted to enter the range to calibrate whenever you enter a calibration command from the front panel. Press **HIGH** or **LOW** followed by the **ENTR** button to proceed with the calibration. To calibrate the other range you must exit to the sample menu and restart the calibration. See Section 4.6 for more information on the Range Modes. The following procedure shows an example of how to calibrate the two ranges with calibration gas coming in through the sample port:

Step	Action	Comment
1.	Press CAL	Analyzer enters M-P calibration mode. Calibration gas source should be set to deliver zero gas to the sample port.
2.	Press LOW-ENTR	Select range to calibrate
3.	Wait 15 min.	Wait for CO ₂ reading to stabilize at zero value.
4.	Press ZERO-ENTR	Changes calibration equations for Low range so analyzer will read zero.
5.	Press CONC	Enter span gas concentration for Low range.
6.	Key in span concentration	Enter span gas concentration for Low Range. Set calibration gas source to deliver span concentration
7.	Press ENTR	
8.	Wait 15 min.	Wait for CO ₂ reading to stabilize at span value
9.	Press SPAN-ENTR	Changes calibration equations for Low range so analyzer will read span value.
10.	Press EXIT	Exits back to sample menu
Repeat steps 1-10 for High range.		

3.2 Zero/span valves (Option)

If the Zero/Span Valves option has been installed the operator can check the zero and span setpoints of the analyzer at any time by pressing the **CALZ** or **CALS** button.

Pressing **CALZ** switches the Sample/Cal valve and allows the analyzer to draw air through the sample port. After a few minutes the CO₂ reading should go to zero. If it doesn't, the operator may press the **ZERO** button followed by **ENTR**.

CALS works like **CALZ** except that externally supplied span gas is drawn through the analyzer. After a few minutes the CO₂ reading should approach the span level (typically 400 PPM). If it doesn't, the operator may press the **SPAN** button, followed by **ENTR**. The expected span gas concentration may be changed by pressing the **CONC** button.

3.3 Automatic zero/span check

Automatic zero/span checking (Z/S check) must be enabled in the setup mode. The Teledyne API Model 360U Carbon dioxide Analyzer with Zero/Span Valves option offers capability to check the zero and span point automatically on a timed basis, or through remote RS-232 operation (see Section 3.7).

Under the **SETUP-ACAL** menu, there are three separate auto-sequences called SEQ1, SEQ2, and SEQ3. Under each SEQ, there are eight setup parameters that affect zero/span checking: the mode, the starting date of the check, the time of day for check, the number of delay days, time delay, the duration of the check, the range to check and whether to calibrate as well as check the range. These are described individually below. Use the **PREV** and **NEXT** buttons to scroll through the three sequences. The mode for each sequence is displayed. To change the mode for any of the sequences, scroll to the desired sequence and press the **MODE** button. Use the **PREV** and **NEXT** buttons to select one of the modes shown below and press **ENTR**.

Mode:

1. DISABLED (Sequence is disabled)
2. ZERO
3. SPAN
4. ZERO-SPAN

To change the setup parameters for a sequence, press the **SET** button. Pressing the <**SET** and **SET**> buttons allows you to scroll through the setup parameters and edit them by pressing the **EDIT** button. The function of each setup parameter is described below:

Timer Enabled: When set to **ON**, the sequence will be executed based on the internal timer, as specified in the following parameters. When set to **OFF** the sequence will be executed only upon an external (RS-232) command.

Starting Date: The starting date for the sequence is entered in the format of MM/DD/YY, where MM is the month, DD is the date, and YY is the year. Enter starting date and press **ENTR** or **EXIT** to leave the date unchanged.

Starting Time: To set the time of day for the sequence, enter in the format HH:MM, where HH is the hour in 24-hour format (i.e. hours range from 00 to 23) and MM is the minute (00 - 59). Enter the time of day for calibration check and then press **ENTR** to accept the new time or **EXIT** to leave the time unchanged.

NOTE

THE PROGRAMMED START TIME MUST BE A MINIMUM OF 5 MINUTES LATER THAN THE PRESENT TIME (SEE SECTION 4.3 AND 4.4 FOR SETTING PRESENT TIME).

Delta Days: The number of delta days is the number of days between each auto-sequence. Enter desired number of delay days (0-365) and press **ENTR**.

Delta Time: The delta time allows the automatic Z/S check time-of-day to be delayed in the format of HH:MM, where HH is the hour from 00 to 23 and MM is the minutes(00-59). The delta days and delta time are added together to determine the total delay between sequences. The delta time parameter allows you to advance or retard the starting time by a fixed amount each time the sequence is run. For example: Setting the delta days to 1 day and the delta time to 15 minutes will delay the starting time for the sequence by 15 minutes each day. If you want to have the sequence run at the same time every day, simply set the delta time to zero.

NOTE

AVOID SETTING TWO OR MORE SEQUENCES AT THE SAME TIME OF THE DAY. ANY NEW SEQUENCE WHICH IS INITIATED WHETHER FROM A TIMER, THE RS-232, OR THE CONTACT CLOSURE INPUTS WILL OVERRIDE ANY SEQUENCE WHICH IS IN PROGRESS.

Duration: The duration of each step of the sequence. Enter the duration in minutes (1-60) and press **ENTR**.

Calibrate: When set to **ON**, the sequence will adjust the internal formulas (slope and offset) in the analyzer to the value set in the span variable. If this feature is enabled along with the automatic zero/span check, the analyzer will re-adjust its formulas to match the predetermined zero and span settings once each day.

Range To Cal: This setup parameter is enabled only if the range mode is set to Dual or Auto. This parameter determines which range the sequence will check.

NOTE

**THE CALIBRATE FEATURE OF AUTO SEQUENCES
ALTERS THE FORMULAS USED TO COMPUTE THE
CARBON DIOXIDE READING.**

Examples of possible sequences are as following under any one of three available SEQx.

Example 1: to perform a 15 minute zero check once per day at 10:30 pm, 12/20/93.

1. MODE: ZERO
2. TIMER ENABLED: ON
3. STARTING DATE: 12/20/93
4. STARTING TIME: 22:30
5. DELTA DAYS: 1
6. DELTA TIME: 00:00
7. DURATION: 15
8. CALIBRATE: OFF

Example 2: to perform a 15 min zero span check once per day retarding 15 minutes everyday starting at 11:30 PM, 12/20/93.

1. MODE: ZERO-SPAN
2. TIMER ENABLED: ON
3. STARTING DATE: 12/20/93
4. STARTING TIME: 23:30
5. DELTA DAYS: 0
6. DELTA TIME: 23:45
7. DURATION: 15
8. CALIBRATE: OFF

Example 3: to perform span check once per week starting at 11:30 pm, 12/20/93

1. MODE: SPAN
2. TIMER ENABLED: ON
3. STARTING DATE: 12/20/93
4. STARTING TIME: 23:30
5. DELTA DAYS: 7
6. DELTA TIME: 00:00
7. DURATION: 15
8. CALIBRATE: OFF

Example 4: to perform zero check once per day at 10:30 pm and a span check once per week starting at 11:30 pm, 12/20/93.

1. Select any one of SEQx and program as example 1.
2. Select any other SEQx and program as example
3. Avoid setting two or more sequences at the same time of the day.

3.4 Summary of front panel check and calibration controls

The calibration controls are summarized below in terms of the button sequences used to access them.

CALIBRATION CONTROLS

Button Sequence	Function	Default	Limits
CALZ	Begin zero check	-	-
CALZ-ZERO-ENTR	Adjust CO ₂ conc. to zero	-	-
CALZ-EXIT	Exit zero check	-	-
CALS	Begin span check	-	-
CALS-CONC-ENTR	Expected CO ₂ span value	800 PPB	100PPB - 100PPM
CALS-SPAN-ENTR	Adj. CO ₂ conc. to span val.	-	-
CALS-EXIT	Exit span check	-	-
CAL	Begin M-P cal.	-	-
CAL-ZERO-ENTR	Adj. CO ₂ conc. zero value	-	-
CAL-CONC-ENTR	Expected CO ₂ span value	800 PPB	100PPB - 100PPM
CAL-SPAN-ENTR	Adj. CO ₂ conc. to span val.	-	-
CAL-EXIT	Exit M-P cal.	-	-
SETUP-ACAL-SEQ1	Setup auto-cal SEQ1	Disabled	
SETUP-ACAL-SEQ2	Setup auto-cal SEQ2	Disabled	
SETUP-ACAL-SEQ3	Setup auto-cal SEQ3	Disabled	

TABLE 3.1

3.5 Remote zero/span check or adjustment (contact closure)

In addition to adjustment via the front panel buttons, the analyzer can be adjusted by means of two contact closures called EXT_ZERO_CAL and EXT_SPAN_CAL. (See Figure 1.3 for the location of the terminals for connection of the contacts on the rear panel.) The CPU monitors these two contact closures every 1 second and looks for a positive transition (i.e. 0→1) on either signal. If a positive transition occurs on EXT_ZERO_CAL, the CPU will perform a zero check. If a positive transition occurs on EXT_SPAN_CAL, the CPU will perform a span check. When a negative transition (i.e. 1→0) is detected, the CPU will go into hold-off.

Also, if a positive transition occurs on either signal while the M360U is in zero, span check or hold off, it will immediately switch to the specified mode. For example, if the analyzer is in zero check and a positive transition is detected on EXT_SPAN_CAL, then the instrument will immediately go into span check. To perform a zero check followed by a span check, first generate a positive transition on EXT_ZERO_CAL, and then when you want to do the span check, generate a positive transition on EXT_SPAN_CAL.

The remote calibration signals may be activated in any sequence, providing a virtually unlimited number of calibration types.

Remote adjustment is similar to automatic Z/S checking in that if dynamic calibration is enabled, the internal CO₂ formulas will be modified following calibration. To enable or disable adjustment, press **SETUP-MORE-VARS** and press **NEXT** until the variable DYN_ZERO or DYN_SPAN is displayed. To change the setting, toggle the value between OFF - ON and press **ENTR** to store the new value or **EXIT** to leave the value unchanged.

NOTE

TELEDYNE API RECOMMENDS THAT CONTACT CLOSURES REMAIN CLOSED AT LEAST 10 MINUTES TO ALLOW FOR AN ACCURATE AVERAGE ZERO OR SPAN VALUE TO BE ESTABLISHED.

NOTE

REMOTE ZERO AND SPAN ADJUSTMENT ALTER THE FORMULAS USED TO COMPUTE THE CARBON DIOXIDE READINGS IF DYN_ZERO OR DYN_SPAN ARE ENABLED.

3.6 Remote zero/span check or adjustment (RS-232)

Besides Z/S checking from the front panel, automatic Z/S checking, and remote Z/S checking via the contact closure inputs, the analyzer can also be checked via the RS-232 interface. Remote checking via the RS-232 interface supports zero, span, and zero followed by span check, and is identical to remote check via the contact closure inputs. This RS-232 control feature is provided mainly so that a host computer at another location can control the analyzer. See Section 7.0 for detailed information on using the RS-232 interface to do a remote Z/S check.

3.7 Power-on hold off

Whenever the Model 360U is powered on it will go through a HOLD-OFF sequence (see Section 3.8, below) as it does after a zero/span check.

3.8 Hold off

Every type of check or adjustment (zero, span, manual, remote, etc.) is followed by a hold off period of from 1 to 20 minutes, during which time the internal data acquisition system (DAS) does not accumulate CO₂ readings into the DAS average. To set the hold off time, press **SETUP-MORE-VARS** and press **NEXT** until the variable **HOLDOFF_TIME** is displayed. To change the setting, enter a number from 1 to 20 and then press **ENTR** to store the new value or **EXIT** to leave the hold off time unchanged.

4.0 SETUP MODE

This section describes the setup variables which are used to configure the analyzer.

4.1 Setup mode operation

ALL the setup variables are stored in the analyzer's EEPROM and are retained during power off and even when new software revisions are installed.

NOTE

**IF A VARIABLE IS MODIFIED, BUT ENTR IS NOT
PRESSED, THE VARIABLE WILL NOT BE CHANGED
AND THE ANALYZER WILL BEEP WHEN EXIT IS
PRESSED.**

4.2 Examining the carbon dioxide formula slope and offset

The slope and offset parameters can be examined by pressing the <TST or TST> buttons until the slope and offset test functions appear. The slope and offset parameters are set only during zero and span calibration routines. These parameters are used to adjust the span and zero values to their exact values.

The current value of the carbon dioxide reading that is displayed on the front panel and output on the D/A terminals on the back panel is computed as follows:

1. Every 160 msec, the analyzer takes a CO₂ MEAS reading (i.e. a reading of the detector output with the IR beam passing through the N₂ cell of the Gas Filter Wheel) and a CO₂ REF reading (i.e. a reading of the detector output with the IR beam passing through the CO₂ Cell of the Filter Wheel).
2. A raw (uncorrected, non-linearized) CO₂ concentration value is calculated according to the following equation:

$$\text{CONCENTRATION} = \text{GAIN_CONST} \times (1 - \text{CO}_2_MEAS / \text{CO}_2_REF + \text{ZERO_CONST})$$

3. Slope and offset corrections are made to the CO₂ concentration according to the equation:

$$\text{CORRECTED CONCENTRATION} = \text{SLOPE} \times \text{MEASURED CONCENTRATION} + \text{OFFSET}$$

4. The concentration value is linearized over the range of 0 to 1000 ppm by a multi-point software look-up table and corrected for temperature and pressure.
5. An average of the last 200 samples is computed and converted to the number displayed on the front panel. This is the carbon dioxide concentration. The number is also routed to the D/A converter and the resulting voltage is output to the back panel.

4.3 Setting the time-of-day

To set the current time-of-day, which is used for determining when to do an automatic calibration and for time-stamping the RS-232 reports, press **SETUP-CLK-TIME**. The CPU will display the current time-of-day as four digits in the format "HH:MM", where "HH" is the hour in 24-hour format (i.e. hours range from 00 to 23) and "MM" the time-of-day and then press **ENTR** to accept the new time, or press **EXIT** to leave the time unchanged.

4.4 Setting the date

To set the current date, which is used for time-stamping the RS-232 reports, press **SETUP-CLK-DATE**. The CPU will display the current date as "DD MMM YY". For example, April 1, 1990 would be displayed as "01 APR 90". Change the date by pressing the button under each field until the desired date is shown. Then press **ENTR** to accept the new date or press **EXIT** to leave the date unchanged.

4.5 Adjusting the clock speed

In order to compensate for clocks which run a little bit fast or slow, there is a variable to speed up or slow down the clock by a fixed amount every day. To change this variable, press **SETUP-MORE-VARS**. Press **NEXT** until the **CLOCK_ADJ** variable is displayed. To change the setting, press the **EDIT** key and enter the value from the keyboard. Press **ENTR** to accept the change. This variable is set to the number of seconds per day by which to speed up or slow down the clock. It should only need to be set once for each analyzer. For example, if the clock is running 10 seconds fast each day, set the variable to -10 and press **ENTR**. (Note that -10 indicates that we want the clock to run 10 seconds slower each day.) If the clock is running 10 seconds slow each day, set the variable to +10, indicating that we want the clock to run 10 seconds faster each day.

If the clock speed adjust variable has already been set to a value other than 0 and the speed is still too fast or too slow, **ADD** the required adjustment to the current value of the

variable. For example if the clock speed adjustment is already set to +10 and the clock is 5 seconds too slow per day, add +5 to the current value, yielding +15 as the new value.

4.6 Setting the CO₂ concentration range

The CO₂ concentration range is the concentration value that corresponds to the maximum voltage output at the rear panel (usually 5 volts). The Model 360U can operate in one of three analog output Range Modes. The Range Mode can be changed through the **SETUP-RNGE-MODE** menu. The modes are described below:

4.6.1 Single range mode (SNGL)

In this mode, both analog outputs (REC and DAS) are set to the same range. This range can be set to any value between 1 and 100 ppm and is accessed through the **SETUP-RNGE-SET** menu. This is the default range mode for the analyzer.

4.6.2 Dual range mode(DUAL)

Selecting dual range mode will allow you to select different ranges for the REC and DAS analog outputs. The two ranges are called Low and High. The REC output at the rear panel is used for the Low range and the DAS output is used for the High range. To set the ranges press **SETUP-RNGE-SET** and select which range you want to edit followed by **ENTR**.

The High and Low ranges have separate slopes and offsets for computing the carbon dioxide concentration. Therefore, the two ranges must be independently calibrated. See Section 3.1.2 for details on calibrating the two ranges.

4.6.3 Auto range mode(AUTO)

In auto range mode, the analyzer automatically switches between the Low and High range depending on the concentration. When the CO₂ concentration increases to 98% of the Low range value, the analyzer will switch to the High range. The analyzer will remain in the High range until the CO₂ concentration drops to 75% of the Low range value. It will then switch back to the Low range. Auto ranging changes the range for the REC and DAS outputs simultaneously. To set the ranges press **SETUP-RNGE-SET** and select which range you want to edit followed by **ENTR**.

The High and Low ranges have separate slopes and offsets for computing the carbon dioxide concentration. Therefore, the two ranges must be independently calibrated. See Section 3.1.3 for details on calibrating the two ranges.

4.7 Setting the analog output offset

In order to permit the analyzer to connect to a wider variety of strip chart recorders and other instruments, the analog output of the carbon dioxide readings can be adjusted by up to ± 500 mV for 0-5V range (or $\pm 10\%$ of current analog output range) in software. The default output offset is 0 mV. To change it, press **SETUP-MORE-DIAG**, press **NEXT**

until D/A CALIBRATION is displayed and press **ENTR**. Press **CFG** to enter the D/A configuration menu. Use the **NEXT** and **PREV** buttons to select the desired analog output and press **SET**. Enter a value of from -500 mV to +500 mV (other ranges will ratio accordingly), followed by **ENTR** to accept the change, or **EXIT** to leave it unchanged. The offset will be reflected immediately on the strip chart recorder or other instrument.

4.8 Setting the RS-232 baud rate

To set the baud rate for the RS-232 channel, press **SETUP-MORE-COMM-BAUD**. Press **300**, **1200**, **2400**, **4800**, **9600**, or **19.2** followed by **ENTR** to accept the new baud rate, or **EXIT** to leave the baud rate unchanged.

4.9 Setting the analyzer I.D.

Each analyzer may be programmed with a unique I.D. number which appears on all RS-232 messages. To set the analyzer I.D., press **SETUP-MORE-COMM-ID**. Enter a 4-digit number from 0000 to 9999, followed by **ENTR** to accept the new I.D., or **EXIT** to leave the I.D. unchanged. If changed, the new I.D. number will appear on all RS-232 reports from this analyzer.

4.10 Disabling the calibration password

Normally, operators are required to enter the calibration password when doing a manual calibration via the **CALZ**, **CALS**, or **CAL** buttons. To allow calibration without entering the password, press **SETUP-PASS** and set it to OFF, and then press **ENTR** to accept the change, or **EXIT** to leave it unchanged. To enable the calibration password, set the variable to ON.

4.11 Data acquisition system (DAS)

The Model 360U contains a flexible and powerful built in data acquisition system (DAS) that enables the analyzer to store concentration data as well as many diagnostic parameters in its battery backed memory. This information can be viewed from the front panel or printed out through the RS-232 port. The diagnostic data can be used for performing “Predictive Diagnostics” and trending to determine when maintenance and servicing will be required.

The logged parameters are stored in what are called “Data Channels.” Each Data Channel can store multiple data parameters. The Data Channels can be programmed and customized from the front panel. A set of default Data Channels has been included in the Model 360U software. These are described Section 4.11.1. For more information on programming custom Data Channels, a supplementary document containing this information can be requested from Teledyne API.

4.11.1 Data Channels

The function of the Data Channels is to store, report, and view data from the analyzer. The data may consist of carbon dioxide concentration, or may be diagnostic data, such as the sample pressure or detector output.

The M360U comes pre-programmed with a set of useful Data Channels for logging carbon dioxide concentration and predictive diagnostic data. The default Data Channels can be used as they are, or they can be changed by the user to fit a specific application. They can also be deleted to make room for custom user-programmed Data Channels.

The data in the default Data Channels can be viewed through the **SETUP-DAS-VIEW** menu. Use the **PREV** and **NEXT** buttons to scroll through the Data Channels and press **VIEW** to view the data. The last record in the Data Channel is shown. Pressing **PREV** and **NEXT** will scroll through the records one at a time. Pressing **NX10** and **PV10** will move forward or backward 10 records. For Data Channels that log more than one parameter, such as PNUMTC, buttons labeled **<PRM** and **PRM>** will appear. These buttons are used to scroll through the parameters located in each record.

The function of each of the default Data Channels is described below:

- CONC:** Samples carbon dioxide concentration (Low Range) at one minute intervals and stores an average every hour with a time and date stamp. Readings during calibration and calibration hold off are not included in the data. The last 800 hourly averages are stored.

- PNUMTC:** Collects sample pressure data at five minute intervals and stores an average once a day with a time and date stamp. This data is useful for monitoring the condition of the sample filter (clogging indicated by a drop in sample pressure) over time to predict when maintenance will be required. The last 360 daily averages (about 1 year) are stored.

- CALDAT:** Logs new slope and offset every time a zero or span calibration is performed. This Data Channel also records the instrument reading just prior to performing a calibration. *Note:* this Data Channel collects data based on an event (a calibration) rather than a timer. This Data Channel will store data from the last 200 calibrations. This does not represent any specific length of time since it is dependent on how often calibrations are performed. As with all Data Channels, a time and date stamp is recorded for every data point logged.

4.11.2 Setting-up Data Channels

To setup a new data channel or modify an existing data channel, press **SETUP-DAS-EDIT** to get into the DAS edit mode.

Once in the DAS edit mode, definitions of data channels may be created or modified by using the MENU buttons described in the following table:

Data Channel Edit Menu	
Button	Description
PREV	MOVES TO THE PREVIOUS DATA CHANNEL
NEXT	MOVES TO THE NEXT DATA CHANNEL
INS	INSERTS A NEW DATA CHANNEL IN FRONT OF THE CURRENT ONE (ALLOWED UP TO 20 DATA CHANNELS)
DEL	DELETES THE CURRENT DATA CHANNEL (PROMPTS FIRST)
EDIT	EDITS THE PROPERTIES OF THE CURRENT DATA CHANNEL
PRNT	PRINTS A SUMMARY OF ALL OF THE DATA CHANNEL ON THE RS-232 PORT

The creation or modification of data channel definitions is accomplished by modifying the *properties* of existing (or default) channel definitions. The following table lists all of the properties defined for data channels.

Data Channel Properties			
Property	Description	Initial Setting	Setting Range
NAME	The data channel's name (primarily used for RS-232 access and reports)	"NONE"	Up to 6 letters or numbers
EVENT	The event which triggers this data channel to record a sample or issue a report	ATIMER	Any of the events listed in the table of triggering events shown above
PARAMETERS	The number of parameters sampled	1	1 to 10
REPORT PERIOD	The amount of time between each report	000:01:00	000:00:01 to 366:23:59 (Days:Hours:Minutes)
NUMBER OF RECORDS	How many reports will be stored in the data file	100	1 to 1000
RS-232 REPORT	Indicates whether or not a report will be printed on the RS-232 channel	OFF	OFF or ON
CHANNEL ENABLED		ON	ON or OFF
CAL. HOLD OFF		ON	ON or OFF

NAME

This property is primarily for the user's convenience, and the user should select meaningful names (you can give a data channel any name you want, up to six characters long). Blank names (all dashes) or duplicate names should be avoided because they won't be accessible from the RS-232 interface.

EVENT

This property designates the event that will trigger data collection. Since this could be a diagnostic tool, it might be useful to read the parameter that is associated with the events such as the calibration. A data channel can be triggered by only one event. If you must trigger collection of the same data by multiple events, then you can create multiple data channels and trigger each one with a different event. The list of available triggering events is shown in following table.

Triggering Events	
Name	Description

ATIMER	Automatic timer expired
EXITZR	Exit zero calibration
EXITSP	Exit span calibration
EXITMP	Exit multi-point calibration
SLPCHG	Slope changed

REPORT PERIOD

This property specifies the period between reports (DAS entries). Enter the number of days and press **ENTR**. Then enter the number of hours (the leftmost digits) and minutes and press **ENTR**.

NUMBER OF RECORDS

This property specifies how many records you want to store in this data channel. Each record consists of a time stamp and the sampled measurements from each parameter. The memory of the M360U has capacity for a total of about 8,000 records (for *all* data channels). When the specified number of records for a data channel has been reached, the channel will “wrap around”, with the oldest records being overwritten with the newest records.

NOTE

CHANGING THIS PROPERTY REQUIRES THAT ANY EXISTING DATA RECORDS BE DELETED BECAUSE MEMORY MUST BE RE-INITIALIZED.

Enter the number of records desired and press **ENTR**. Only when you press **ENTR** is the data file actually deleted. If you press **EXIT** the property will not be modified and data file will not be deleted.

RS-232 REPORT

This property controls printing of reports on the RS-232 channel. If set to ON then every time a new report is stored it's also printed on the RS-232 channel. If this property is set to OFF, the reports are still stored in the data file, but not printed on the RS-232 channel.

PARAMETERS

This property shows the *number* of parameters being sampled. Each data channel can sample up to 10 parameters, each with a separate sampling mode.

This parameter also specifies the *mode* of data collection. When sampling a reading such as a concentration at periodic intervals, it is desirable to use the *AVG mode* to generate an average of the readings during the interval. But when sampling the concentration when

exiting calibration it is desirable to take a single instantaneous reading using the *INST* mode. The table below summarizes the available sampling modes.

Sampling Modes	
Mode	Description
INST	Records instantaneous reading
AVG	Records average reading during reporting interval
MIN	Records minimum reading during reporting interval
MAX	Records maximum reading during reporting interval

Each parameter in this list can refer to a different (or the same) point, and can use a different (or the same) sampling mode. For instance, you could create three parameters which all measure the CO₂ concentration for range 1 (the CONC1 parameter), but which use the MIN, AVG, and MAX sampling modes. This permits you to record not only the average concentration during the reporting interval, but the maximum excursions as well. Like data channels, parameters also have properties which are listed in the table below.

Parameter Properties			
Property	Description	Initial Setting	Setting Range
PARAMETER	The parameter to sample	CONC1	Any of the parameters listed in the table of parameters shown above
SAMPLE MODE	The sampling mode to use when reading this parameter	AVG	Any one of the INST, AVG, MIN, and MAX.
PRECISION	Number of decimal digits	1	0 - 3

The table below lists the data parameters initially defined. The entries in the Name and Units columns are visible when editing and printing the data channel properties.

Data Parameters		
Name	Description	Units
NONE		
DETMEAS	CO ₂ Measure signal	mV
DETREF	CO ₂ Reference signal	mV
SLOPE1	Slope of Range #1	
SLOPE2	Slope of Range #2	
OFSET1	Offset of Range #1	mV
OFSET2	Offset of Range #2	mV
ZSCNC1	Range1 zero/span measured concentration	PPM
ZSCNC2	Range2 zero/span measured concentration	PPM
CONC1	Concentration of Range #1	PPM
CONC2	Concentration of Range #2	PPM
STABIL	Stability	PPM
BENCHTMP	Optical bench temperature	°C
WHEELTMP	Filter wheel temperature	°C
SMPPRS	Sample pressure	in-Hg
BOXTMP	Box temperature	°C
DCPS	DC power supply composite voltage	mV

Example:

Sample the CO₂ concentration (Range #1) once per minute (default) and issue a report once per 5 minutes, and print the report on the RS-232 channel.

1. Press **SETUP-DAS-EDIT-ENTR-INS** to create a new data channel and begin editing its properties.
2. Edit the NAME property and give it any name you want, but do not set the blank name (all dashes) or duplicate names because they won't be accessible from the RS-232 interface.
3. For each of the remaining properties, press the SET> to view the current setting, and then press **EDIT** to change the property if necessary. The following table lists the proper settings for all of the properties for this example:

Property	Setting	DESCRIPTION
NAME	“CO25MIN”	
EVENT	ATIMER	Sample when automatic timer is expired
PARAMETERS	CONC1,AVG	CO ₂ Range #1 concentration
REPORT PERIOD	000:00:05 (i.e. 5 minutes)	Average of 5 minutes* reported every 5 minutes
NUMBER OF RECORDS	4032 (i.e. two weeks)	Stores 4032 of Report Period (5 minutes average)
RS-232 REPORT	ON	RS-232 is enabled
CHANNEL ENABLED	ON	Data channel is enabled
CAL. HOLD OFF	ON	Hold off is enabled

*Sample measurement period of filtered CO₂ concentration is 1 minute by default.

4.11.3 RS-232 reporting

Automatic RS-232 reporting can be independently enabled and disabled for each Data Channel. For all default data channels, RS-232 reporting is initially set to “OFF.” If this property is turned on, the Data Channel will issue a report with a time and date stamp to the RS-232 port every time a data point is logged. The report format is shown below:

```
D 31:10:06 0412 CONC : AVG CO2CNC1=6.8 PPM
```

The report consists of the letter “D” followed by a time/date stamp (“31:10:06”) followed by the instrument ID number (“0412”). Next is the Data Channel name (“CONC”) and the sampling mode (“AVG” indicates that the data point is an average of more than one sample as opposed to an instantaneous reading, “INST”). Finally, the name of the parameter and its value (“CO2CNC1=6.8 PPM”) are printed. For Data Channels that sample more than one parameter, such as PNUMTC and CALDAT, each parameter is printed on a separate line.

To enable RS-232 reporting for a specific Data Channel:

Step	Action	Comment
1.	Press SETUP-DAS-EDIT	Enter DAS menu to edit Data Channels
2.	Press PREV/NEXT	Select Data Channel to edit
3.	Press EDIT	Edit selected Data Channel
4.	Press SET> (5 times)	Scroll through setup properties until RS-232 REPORT: OFF is displayed
5.	Press EDIT	Edit selected setup property
6.	Toggle OFF to ON	Change RS-232 REPORT property
7.	Press ENTR	Accepts change
8.	Press EXIT (4 times)	Exits back to sample menu

See Section 7.1 for more information on DAS reporting through the RS-232 interface.

4.12 Software configuration

The software configuration can be displayed by entering the button sequence **SETUP-CFG-LIST**. For example the M360U could display:

"CO2 MACHINE"
"SBC40 CPU"

Stating that the instrument was an Carbon dioxide analyzer using the SBC40 computer. This feature is useful for showing any special features that are present in the currently installed PROM.

4.13 Gas Alarms

An alarm is activated if the gas concentration is above the set limit or an out of limit condition exists. When the gas alarm is triggered, either status output 1 or 2 is closed. See Table 1.1 for the status output.

NOTE

SPAN GAS CONCENTRATION MAY TRIGGER GAS ALARMS UNLESS THE ANALYZER IS IN THE CALIBRATION MODE. PRESS CAL BUTTON PRIOR TO INTRODUCING SPAN GAS INTO THE ANALYZER.

There are two types of alarms called ALM1 and ALM2. The user can change the setting of each of the alarm concentration limit. Press SETUP-MORE-ALRM, then select either

ALM1 or ALM2, and toggle ON-OFF followed by ENTR. When the concentration entry field is shown, enter the desired limit concentration value and press ENTR.

4.14 Summary of setup functions

The setup functions are summarized in Table 4.1 in terms of the button sequences used to access them.

SETUP FUNCTIONS

Button Sequence	Function	Default	Limits
SETUP-CFG-NEXT	List Software Configuration	CO2 Mach	N/A
SETUP-ACAL-MODE	Define/Change AutoCal Sequences	Disabled	Zero, Span, Zero-Span
SETUP-DAS-EDIT	Define/Change DAS Data Channels		
SETUP-DAS-VIEW	View DAS Data	N/A	N/A
SETUP-RNGE-MODE	Set Range Mode	Single	Single, Dual, Auto
SETUP-RNGE-SET	Set D/A output range	500 ppm	100-1000 ppm
SETUP-RNGE-UNIT	Set Measurement Units	ppm	ppb, ppm, mg/m3, ug/m3
SETUP-PASS	Password Enable	ON	OFF-ON
SETUP-CLK-TIME	Set Time-of-Day	00:00	00:00-23:59
SETUP-CLK-DATE	Set Current Date	01 JAN 00	31 DEC 99
SETUP-MORE-COMM-BAUD	RS-232 baud rate	19.2 K baud	300, 1200, 2400, 4800, 9600, 19.2
SETUP-MORE-COMM-ID	Analyzer ID number	0000	0000-9999
SETUP-MORE-VARS-DAS_HOLD_OFF	Set Hold-Off Interval	15 min	1 - 60 min
SETUP-MORE-VARS-DYN_ZERO	Enable Remote Dynamic Zero Adjustment	OFF	OFF-ON
SETUP-MORE-VARS-DYN_SPAN	Enable Remote Dynamic Span Adjustment	OFF	OFF-ON
SETUP-MORE-VARS-RS232_MODE	Set RS-232 Mode	8	
SETUP-MORE-VARS-CLOCK_ADJ	Set Clock Adjustment Rate	0	-15 to +15

SETUP-MORE-DIAG-SIGNAL I/O	View the state of internal signals	N/A	N/A
SETUP-MORE-DIAG-ANALOG OUTPUT	Generate Analog Output Test Pattern	N/A	N/A
SETUP-MORE-DIAG- D/A CALIBRATION	Calibrate D/A and A/D Converters	N/A	N/A
SETUP-MORE-DIAG-ELECTRICAL TEST	Generate Electrical Test Output	N/A	N/A
SETUP-MORE-DIAG- DARK CALIBRATION	Adjust Dark Offset	125mV	75-175mV
SETUP-MORE- DIAG- TEST CHAN OUTPUT	Select TEST to Analog Output	None	
SETUP-MORE-DIAG-RS-232 OUTPUT	Generate RS-232 Output Test Pattern	N/A	N/A
SETUP-MORE-ALRM-ALM1	Enable alarm 1 and set limit	ON	100 PPM
SETUP-MORE-ALRM-ALM2	Enable alarm 2 and set limit	ON	300 PPM

TABLE 4.1

5.0 DIAGNOSTICS

The Teledyne API Carbon dioxide analyzer contains two levels of diagnostics: test measurements which can be viewed at all times (except when in setup) by pressing **TEST**, and lower level diagnostic operations which can only be performed by pressing **SETUP-MORE-DIAG**.

5.1 Test measurements

As stated, test measurements can be viewed at any time except when in setup. To view a different test measurement, simply press the **TEST** button. Table 2.3 lists the test measurements which are available. Viewing these test measurements does not interfere with the operation of the Model 360U or the Carbon dioxide reading in any way, so they may be viewed freely.

NOTE

IF THE VALUE OF ANY TEST FUNCTION IS DISPLAYED AS "XXXX", THIS INDICATES THAT THE READING IS OFF SCALE OR OTHERWISE NON-VALID.

Additionally, the values of most **TEST** functions can output as an analog voltage at the instrument's rear panel (see Figure 1.3). The **TEST** function to be output is selected by pressing **SETUP-MORE-DIAG**. Press **NEXT** until **TEST CHANNEL OUTPUT** appears. Press **ENTR**. Select test channel function and press **ENTR**. Table 5.1 lists the Test functions available for analog output.

In addition to outputting a value to the analog output channel, these tests activate a new test measurement which displays the analog voltage reading on the front panel as:

"TEST=XXXXX.X MV".

When you exit the diagnostics, this test measurement is removed.

5.2 Diagnostic tests

The diagnostic tests are used to help diagnose a problem in the analyzer and should only be used by skilled maintenance people since they can potentially interfere with the carbon dioxide reading. Table 5.1 lists the low level diagnostic tests which are available. To get into the diagnostic test mode, press **SETUP-MORE-DIAG**. When the diagnostic mode

is entered, a message is sent to the RS-232 channel indicating entry into the diagnostic mode. The buttons which are available to the operator are described below.

The **TEST** button is used to scroll through the test measurements until the one of interest is displayed. To turn the test on press the **OFF/ON** button. Viewing test measurements in the diagnostic mode is especially useful for viewing the results of a diagnostic test.

The **PREV** button goes to the previous diagnostic test. When pressed, the CPU turns the current diagnostic test OFF if it is ON. The **NEXT** button goes to the next diagnostic test. When pressed, the CPU turns the current diagnostic test OFF if it is ON. The **EXIT** button exits the diagnostic mode and turns all the diagnostic tests OFF. This ensures that a diagnostic test is not accidentally left ON. A message is also sent to the RS-232 channel to indicate that the diagnostic mode has been exited.

DIAGNOSTIC TESTS

Test #	Name	Signal	Nominal Value
1	NONE	No output	0 mV
2	CO2 MEASURE	CO ₂ detector measure value	4500 mV
3	CO2 REFERENCE	CO ₂ detector reference value	4200 mV
4	SAMP PRESS	Sample pressure	3650 mV
5	SAMP TEMP	Sample temperature	3000 mV
6	BENCH TEMP	Optical bench temperature	3900 mV
7	WHEEL TEMP	Outputs filter wheel temp.	3900 mV
8	CHASSIS TEMP	Outputs Chassis temp	2740 mV
9	DCPS VOLT	Outputs DC power	2500 mV
10	DAS AVERAGE	Current DAS average	Any

TABLE 5.1

5.2.1 Signal I/O

The signal I/O diagnostic mode gives the user access to the digital and analog inputs and outputs on the V/F board. The digital outputs can be controlled through the keyboard. Any signals manually changed through the signal I/O menu will remain in effect until you leave the signal I/O menu. At that time the analyzer will regain control of these signals. To enter the signal I/O test mode, press **SETUP-MORE-DIAG-ENTR**. When the diagnostic mode is entered, a message is sent to the RS-232 channel indicating entry into the diagnostic mode. Use the **PREV** and **NEXT** buttons to scroll through the signals. Edit buttons will appear for the signals that can be controlled by the user. Press **JUMP** to skip to a specific I/O Signal.

Table 5.2 lists the I/O signals available for the M360.

I/O SIGNALS

#	Signal	Control	Description
0	DISP_BROWNOUT	NO	Display brownout is used to keep the display from getting corrupted during low line voltage conditions. Circuitry on the Power Supply board (00015) senses low line voltage and sets this bit. The CPU reads this and generates the BROWNOUT_RESET signal described below.
1	EXT_ZERO_CAL	NO	Shows state of status input bit to cause the M360U to enter Zero Calibration mode. Use to check external contact closure circuitry.
2	EXT_SPAN_CAL	NO	Shows state of status input bit to cause the M360U to enter the Span Calibration mode. Use to check external contact closure circuitry.
3	SYNC_OK	NO	Indicates that demodulation circuitry on the Sync/Demod Board (00798) is able to lock-in on the detector signal.
4	SPAN_VALVE	YES	Switches the Zero/Span valve. Use this bit to test the valve function.
5	CAL_VALVE	YES	Switches the Sample/Cal valve. Use this bit to test the valve function.
6	BENCH_HTR	YES	Shows the status of the optical bench heater. This has the same function as the LED in the power supply module.
7	WHEEL_HTR	YES	Shows the status of the filter wheel heater. This has the same function as the LED in the power supply module.
8	DARK_CAL	YES	Turns off the detector input to the Sync/Demod board for electronics calibration.
9	ELEC_TEST	YES	Activates the Electric Test diagnostic circuitry.
10	BROWNOUT_RESET	YES	Resets the DISP_BROWNOUT circuitry described above.
11	ST_CONC_ALARM_1	YES	Status Bit - gas alarm 1 Logic high = M360U in alarm 1 mode Logic low = Not in alarm 1 mode
12	ST_CONC_ALARM_2	YES	Status Bit - gas alarm 2 Logic high = M360U in gas alarm 2 Logic low = Not in alarm 2 mode
13	ST_SPARE_ALARM	YES	

14	ST_TEMP_ALARM	YES	Status Bit - Temperature alarm Logic High = One or more temps out of spec Logic Low = Temps within spec
15	ST_DIAG_MODE	YES	Status Bit - In Diagnostic mode Logic High = M360U in Diagnostic mode Logic Low = Not in Diag mode
16	ST_POWER_OK	YES	Status Bit - Power OK Logic High = Instrument power is on Logic Low = Instrument power is off
17	ST_PRESS_ALARM	YES	Status Bit - Pressure alarm Logic High = Sample pressure out of spec Logic Low = pressure within spec
18	ST_HIGH_RANGE	YES	Status Bit - Autorange High Range Logic High = M360U in high range Logic Low = M360U in low range
19	ST_SYSTEM_OK	YES	Status Bit - System OK Logic High = No instrument warning present Logic Low = 1 or more alarm present
20	ST_BENCH_ALARM	YES	Status Bit - Bench Temperature Alarm Logic High = Bench Temp out of spec Logic Low = Bench Temp in spec
21	ST_SOURCE_ALARM	YES	Status Bit - IR Source Alarm Logic High = IR Source output too low Logic Low = IR Source output normal
22	ST_WHEEL_ALARM	YES	Status Bit - Wheel Temperature Alarm Logic High = Wheel Temp out of spec Logic Low = Wheel Temp in spec
23	CO2_MEASURE	NO	IR detector reading during measure phase. Typically 2500-4500 mV
24	CO2_REFERENCE	NO	IR detector reading during reference phase. Typically 2500-4500 mV
25	SAMPLE_PRESURE	NO	Sample pressure in mV. Typical sea level value = 4300mV for 29.9" HG-A.
26	SPARE	NO	
27	SAMPLE_TEMP	NO	Sample temp in mV
28	BENCH_TEMP	NO	Optical Bench temp. Typically 2270 mV for 48°C
29	WHEEL_TEMP	NO	Filter Wheel temp. Typically 4770 mV for 68°C

30	BOX_TEMP	NO	Internal analyzer temp in mV
31	DCPS_VOLTAGE	NO	DC power supply composite voltage output. Typically 2500 mV.
32	DAC_CHAN_0	NO	Output of DAC 0(REC) in mV.
33	DAC_CHAN_1	NO	Output of DAC 1(DAS) in mV.
34	DAC_CHAN_2	NO	Output of DAC 2(TEST) in mV.
35	DAC_CHAN_3	NO	Output of DAC 3(Spare) in mV.
36	CO2_CONC_1	YES	CO ₂ Reading (REC) in mV
37	CO2_CONC_2	YES	CO ₂ Reading (DAS) in mV
38	TEST_OUTPUT	YES	Test Channel in mV
39	SAMPLE_LED	YES	Sample LED on/off
40	CAL_LED	YES	Calibration LED on/off
41	FAULT_LED	YES	Fault LED on/off

TABLE 5.2 I/O SIGNALS

5.2.3 D/A output

This test cycles 3 of the analog output channels from 0% to 100% of full scale in 20% full scale steps. It starts by outputting 0 volts to all four channels and displaying a 0% button. Then, every five seconds, the output is increased 20% FS and the button is changed accordingly. Thus, the button (and the analog outputs) will cycle through the following value

0%, 20%, 40%, 60%, 80%, 100%, 0%, ...

To pause the output at the current voltage, press the **n%** button. To resume automatic cycling, press the **n%** button again.

5.2.4 Electric Test

This test activates a diagnostic circuit located on the Synchronous Demodulator board which generates an artificial signal which simulates the output of the IR detector. This signal is injected in place of the detector output.

When activated, Electric Test will automatically switch the analyzer into a 50 ppm range and result in the analyzer producing a constant, stable output (i.e. CO₂ reading) of about 40 ppm. This test is particularly useful in isolating problems, since it exercises essentially all electronic sub-systems of the analyzer but does not depend on the proper function of optical or pneumatic subsystems.

5.3 M360U Internal Variables

The M360U software contains many adjustable parameters. Many of the parameters are set at time of manufacture and do not need to be adjusted for the lifetime of the instrument. It is possible to change these variables either through the RS-232 port or the front panel. **Altering the values of many of the variables, especially those not listed on table 5.3, will**

adversely affect the performance of the instrument. Therefore it is recommended that these variables not be adjusted unless you have a clear understanding of the effects of the change.

To access the VARS menu press SETUP-VARS-ENTR. Use the PREV-NEXT button to select the variable of interest and press EDIT to examine/change the value, then press ENTR to save the new value. If no change is required, press EXIT.

M360U VARIABLES

No.	Name	Units	Default Value	Value Range	Description
0	DAS_HOLD_OFF	MIN	15	0 - 20	DAS hold off duration after calibration or diagnostic
1	DYN_ZERO		OFF	OFF/ON	Enable to adjust zero calibration through remote contact closure
2	DYN_SPAN		OFF	OFF/ON	Enable to adjust span calibration through remote contact closure
3	RS232_MODE	Bit Field	8	0-99999	Value is SUM of following decimal numbers: 1=enable quiet mode 2=enable computer mode 4=enable security feature 8=enable front panel RS-232 menus (API protocol) 16=enable alternate protocol 32=enables multi-drop support 64=Enable modem 4096=enable command prompt
4	CLOCK_ADJ	Sec.	0	±60	Real-time clock adjustment

TABLE 5.3

6.0 HANDLING WARNINGS

When a system warning occurs, a warning message is displayed and the **FAULT LED** blinks. A warning indicates that something in the system needs to be checked or adjusted. Failure by the operator to respond to a warning may result in poor system performance and/or less accurate data acquisition. Warnings should be taken seriously.

When a warning is displayed, the **MSG** and **CLR** buttons will appear on the menu line (when not in setup mode). Pressing **MSG** will scroll through the warning messages if there is more than one. **CLR** will clear the currently displayed warning message, and if there are no more warning messages remaining, the **MSG** and **CLR** buttons will disappear and the **FAULT LED** will be turned OFF. If after pressing **CLR**, warning messages still exist, the **FAULT LED** will continue to blink and the **MSG** and **CLR** buttons will remain on the menu line.

If after clearing a message, the warning condition for that message still exists, the message will reappear after a period of time which depends on how frequently the condition is checked by the CPU (usually every few seconds). If a warning message reappears every time after **CLR** is pressed, the problem should be solved and the analyzer restarted. Some problems may be temporary and may not reappear after **CLR** is pressed (e.g. temperature too high, too low, etc.).

To ignore the warning messages and display the test measurement again, simply press **TEST**. The warning messages will remain active and may be viewed again by pressing **MSG**.

7.0 RS-232 COMMUNICATIONS

The Model 360U features a powerful RS-232 interface that is used both for reporting test results and for controlling the analyzer from a host computer. Because of the dual nature of the RS-232 interface, the message format has been carefully designed to accommodate both printers and host computers.

Setup from the Front Panel

There are 2 additional RS-232 setups that can be done via the front panel.

1. Set the Instrument ID number by SETUP-MORE-COMM-ID, and enter a 4 digit number from 0000-9999. This ID number is part of every message transmitted from the port.
2. Set the RS-232 mode bit field in the VARS menu. To get to the variable press, SETUP-MORE-VARS-ENTR and scroll to RS232_MODE, then press EDIT. The possible values are:

RS-232 PORT SETUP - FRONT PANEL

Decimal Value	Description
1	Turns on quiet mode (messages suppressed)
2	Places analyzer in computer mode (no echo of chars)
4	Enables Security Features (Logon, Logoff)
8	Enables RS-232 menus display on M360U front panel display
16	Enables alternate protocol and setup menu
32	Enables multi-drop support for RTS
64	Enables modem setup

TABLE 7.1

NOTE

TO ENTER THE CORRECT VALUE, ADD THE DECIMAL VALUES OF THE FEATURES YOU WANT TO ENABLE. FOR EXAMPLE IF LOGON AND FRONT PANEL RS-232 MENUS WERE DESIRED THE VALUE ENTERED WOULD BE $4 + 8 = 12$.

All message outputs from the Model 360U have the following format:

"X DDD:HH:MM IIII MESSAGE<CRLF>"

The "X" is a character indicating the message type (see table below).

RS-232 MESSAGE TYPES

Character	Message Type
W	Warning
C	Control/status
D	Diagnostic
T	Test measurement
V	Variable value
?	HELP screen

TABLE 7.2

The "DDD:HH:MM" is a time-stamp indicating the day-of-year ("DDD") as a number from 1 to 366, the hour of the day ("HH") as a number from 00 to 23, and the minute ("MM") as a number from 00 to 59.

The "IIII" is a 4-digit analyzer I.D. number.

The "MESSAGE" field contains variable information such as warning messages, test measurements, DAS reports, etc.

The "<CRLF>" is a carriage return-line feed combination which terminates the message and also makes the messages appear neatly on a printer.

The uniform nature of the output messages makes it easy for a host computer to spare them.

Input messages to the Model 360U have a format which is similar to that for output messages:

"X COMMAND<CRLF>"

The "X" indicates the message type as shown above in Table 7.2 and "COMMAND" is the command type, each of which is described individually below.

The "<CRLF>" is used to terminate the command. Typing "<CRLF>" a few times by itself is a good way to clear the input buffer of any extraneous characters.

7.1 DAS reporting

Data from individual Data Channels in the DAS system can be retrieved through the RS-232 interface. The command format for printing the data for a Data Channel is shown below:

D [id] REPORT “name” [RECORDS=number] [COMPACT|VERBOSE]

parameters in [] are optional

id is the analyzers ID number (**SETUP-MORE-COMM-ID**)

name is the Data Channel name(must be enclosed in quotes)

number is the number of records to print, beginning with the most recent(if this parameter is not specified then all available records for the Data Channel are printed)

COMPACT|VERBOSE refers to the report format.

Verbose Data Report Format

There are two kinds of data reports: verbose (with a lot of detail) and compact (with just the data point values). The verbose format looks like the following:

```
D 31:10:06 0412 CONC : AVG CO2CNC1=6.8 PPM
```

This report uses the format of a leading first character (“D” in this example), a time stamp (“31:10:06”), and the instrument ID (“0412”).

The other fields in the report are the data collector name (“CONC”), the sampling mode (“AVG”), the data point (“CO2CNC1”), the data point value (“6.8”), and the units (“PPM”). Due to the length of the message, only one data point may be printed per line.

Compact Data Report Format

The compact format looks like the following:

```
D 31:10:06 0412 CONC : 1 6.8
```

The fields up to the colon are the same as for the verbose format, but the next fields are different. The fields following the colon are the line number (“1” in the example), and the data point value (“6.8”). Presumably the user (or remote computer) knows all of the other information about the data point value.

This report format is particularly useful when you are sampling more than one data point because up to five data points may be printed per line. The line number field is necessary because a single report may span multiple lines. A compact report with two data points, such as the PNUMTC Data Channel, looks like this:

```
D 31:10:06 0412 PNUMTC: 1 800.0 29.7
```

Example 1: To report the last 100 records from the CONC Data Channel in Verbose format type:

D REPORT "CONC" RECORDS=100 VERBOSE

Example 2: To report all the records from the PNUMTC Data Channel in Compact format type:

D REPORT "PNUMTC" COMPACT

7.2 Warnings

Whenever a warning message is displayed on the display, it is also sent to the RS-232 output. See Table 2.4 for a list of the warning messages. These messages are very helpful when trying to track down a system problem and for determining whether or not DAS average data is actually valid. The message format is:

```
"W DDD:HH:MM IIII WARNING MESSAGE<CRLF>"
```

An example of an actual warning message is:

```
"W 194:11:03 0000 SAMPLE TEMP WARN<CRLF>"
```

Warnings may be cleared via the RS-232 interface by issuing a command of the form:

```
"W COMMAND<CRLF>"
```

where "COMMAND" indicates which warning message to clear. For example, to clear the "SAMPLE TEMP WARN" message, the host computer can issue the command:

```
"W WSMPTEMP<CRLF>".
```

Attempting to clear a warning that is not active has no effect. The table below lists the command to use to clear each possible warning message.

WARNING MESSAGE CLEAR COMMANDS

Command	Warning Message Cleared
"W WSYSRES<CRLF>"	SYSTEM RESET
"W WRAMINIT<CRLF>"	RAM INITIALIZED
"W WSOURCE<CRLF>"	SOURCE WARNING
"W WBHEAT<CRLF>"	BENCH HEAT SHUTDOWN
"W WWHLTEMP<CRLF>"	WHEEL TEMP WARNING
"W WSMPRES<CRLF>"	SAMPLE PRESSURE WARNING
"W WSMPTEMP<CRLF>"	SAMPLE TEMP WARNING
"W WBOXTEMP<CRLF>"	BOX TEMP WARNING
"W WBNCHTEMP<CRLF>"	BENCH TEMP WARNING
"W WDYNZERO<CRLF>"	CANNOT DYN ZERO
"W WDYNSPAN<CRLF>"	CANNOT DYN SPAN
"W WVFINS<CRLF>"	V/F NOT INSTALLED

TABLE 7.3

7.3 Status/control

This subset of messages is concerned with reporting the status of the analyzer and controlling the analyzer remotely. Whenever the analyzer does a calibration it issues a report to the RS-232 output. The table on the following page summarizes the status reports.

STATUS REPORTS

Report
"C DDD:HH:MM IIII START ZERO CALIBRATION"
"C DDD:HH:MM IIII FINISH ZERO CALIBRATION"
"C DDD:HH:MM IIII START SPAN CALIBRATION"
"C DDD:HH:MM IIII FINISH SPAN CALIBRATION"
"C DDD:HH:MM IIII START MULTI-POINT CALIBRATION"
"C DDD:HH:MM IIII FINISH MULTI-POINT CALIBRATION"
"C DDD:HH:MM IIII START CALIBRATION HOLD"
"C DDD:HH:MM IIII FINISH CALIBRATION HOLD"

TABLE 7.4

To do a remote adjustment via the RS-232 interface, the host computer should issue a message with the following format:

"C COMMAND<CRLF>

The commands are summarized in the table below:

CONTROL COMMANDS

Command Message	Meaning
"C ZERO<CRLF>"	Do a zero check
"C COMPUTE ZERO<CRLF>"	Calibrate Zero point ¹
"C SPAN<CRLF>"	Do a span check
"C COMPUTE SPAN<CRLF>"	Calibrate Span point ¹
"C ASEQ1<CRLF>"	Do a auto-cal sequence ²
"C ASEQ2<CRLF>"	Do a auto-cal sequence ²
"C ASEQ3<CRLF>"	Do a auto-cal sequence ²
"C ABORT<CRLF>"	Aborts auto-cal sequence
"C EXITZ<CRLF>"	Exit zero cal only
"C EXITS<CRLF>"	Exit span cal only
"C EXIT<CRLF>"	Exit zero span or hold
¹ Executed only if the instrument is in the proper calibration mode and concentration is within calibration limits. This command adjusts slope and offset values.	
² Initiated only If automatic calibration sequence setup is programmed and enabled.	

TABLE 7.5

NOTE

THE COMMANDS IN TABLE 7.5 CAN ONLY BE ENTERED VIA THE RS-232 PORT WHEN THE ANALYZER IS IN THE SAMPLE MODE.

When a control command is issued, the CPU will respond by issuing a status report. For example if the host computer issues the command

"C CALZ<CRLF>"

to do a zero check, the CPU will send the status report

"C DDD:HH:MM IIII START ZERO CALIBRATION<CRLF>"

to the RS-232 output.

7.4 Diagnostics

The diagnostics mode can be entered from the RS-232 port as well as from the front panel. The diagnostics commands available are listed on Table 7.6.

NOTE

THE DIAGNOSTICS MODE MAY ONLY BE ENTERED VIA THE RS-232 PORT WHEN THE ANALYZER IS IN SAMPLE MODE.

DIAGNOSTIC COMMANDS

Command	Function
D ENTER SIG	Enter diagnostic Signal I/O mode
D EXIT	Exit diagnostics mode
D LIST	Prints all Signal I/O values. See Table 5.2 for Signal Definitions
D name[=value]	Examines or sets I/O signal. See Table 5.2 for a list of signals. Must issue D ENTER SIG before using this command.

TABLE 7.6

These commands may be used whether the diagnostics have been entered from the keyboard (SETUP-DIAG) or the RS-232 ("D ENTER <CRLF>"). However, when the diagnostics are entered via the keyboard, no feedback is sent to the RS-232 channel. This prevents the RS-232 output from getting unnecessarily cluttered with diagnostic data.

Whenever the diagnostic mode is entered or exited, a report is issued to the RS-232 output. The table below summarizes the diagnostic reports.

DIAGNOSTIC REPORTS

Report
"C DDD:HH:MM III ENTER DIAGNOSTIC MODE"
"C DDD:HH:MM III EXIT DIAGNOSTIC MODE"

TABLE 7.7

7.5 Test measurements

All the test measurements that can be displayed by pressing the TEST button are also available to the host computer via the RS-232 interface. The host computer should issue

a request for a test measurement, and then the CPU will send the current value of the test measurement to the RS-232 output. The format of the test measurement message is:

"T DDD:HH:MM IIII TEST MEASUREMENT<CRLF>"

For example, the format of the DC Power Supply output in millivolts would be:

"T 194:11:29 0000 DCPS= 2500 MV<CRLF>"

To request a test measurement, the host must issue a command of the form:

"T MEASUREMENT<CRLF>"

For a summary of all test functions issue the command "T LIST". The table below lists the commands and the corresponding test measurements which will be returned.

TEST MEASUREMENT REQUEST COMMANDS

Command	Test measurement
"?<CRLF>"	RS-232 HELP screen
"T LIST<CRLF>"	Summary of all TEST's
"T CO2<CRLF>"	Current CO2 reading
"T COMEAS<CRLF>"	Current CO2 MEAS mV
"T COREF<CRLF>"	Current CO2 REF mV
"T MRRATIO<CRLF>"	Current MR RATIO
"T SPRESS<CRLF>"	Sample pressure
"T STEMP<CRLF>"	Sample temperature
"T BNCHTEMP<CRLF>"	Optical Bench temperature
"T WHEELTEMP<CRLF>"	Filter Wheel temperature
"T BOXTEMP<CRLF>"	Internal box temperature
"T DCPS<CRLF>"	DC power supply output
"T CO2SLOPE<CRLF>"	Slope value
"T CO2OFFSET<CRLF>"	Offset value
"T CLKTIME<CRLF>"	Current time-of-day

TABLE 7.8

7.6 Viewing and modifying variables

The most powerful feature of the RS-232 interface is the ability of a host computer to view and modify the analyzer's internal variables. Just as the operator modifies the variables by means of the setup mode, the host computer modifies them by means of the RS-232 interface.

To view a variable's value, the host computer issues a command of the following format:

```
"V VARIABLE<CRLF>"
```

The CPU will respond by sending a message of the following format to the RS-232 output:

```
"V VARIABLE=VALUE WARNLO WARNHI <DATA LO-DATA HI> <CRLF>"
```

In both cases "VARIABLE" is the name of the variable that is being viewed. "VALUE" is the current value of the variable. "WARNLO" and "WARNHI" are the low and high warning limits, respectively, but may not appear for all variables since some variables do not have warning limits. "DATA LO" and "DATA HI" are the low and high data entry limits, respectively, and are given for all variables. The CPU will not set a variable's value or warning limits to values that are outside of the data entry limits.

For example, to see the optical bench temperature set point, the host computer would issue the command:

```
"V BENCH_SET<CRLF>"
```

and the CPU would respond with something like:

```
"V DDD:HH:MM IIII BENCH_SET=48 43 53 <0-100><CRLF>",
```

Indicating that the current set point is 48 degrees, the warning limits are 43 to 53 degrees, and the data entry limits are 0 to 100 degrees.

To modify a variable's value, almost the same format of command is used:

```
"V VARIABLE=VALUE WARNLO WARNHI<CRLF>"
```

The "VARIABLE" field is the name of the variable being modified, and the "VALUE" field is the new value. "WARNLO" and "WARNHI" are the low and high warning limits, respectively, and may only be given if the variable uses warning limits. They are optional for variables that use warning limits and, if not given, the warning limits are not changed.

After changing the variable's value, the CPU will respond with:

```
"V VARIABLE=VALUE WARNLO WARNHI [DATA LO-DATA HI] <CRLF>"
```

which should reflect the new value. The values in square brackets are not required for all variables. If needed, the values are included on the command line, separated by spaces. For example, to change the instrument ID, the host computer would issue a command like this:

```
"V MACHINE_ID=1234<CRLF>"
```

and the CPU should respond with:

```
"V DDD:HH:MM IIII MACHINE_ID = 1234 (0-9999)<CRLF>"
```

Table 7.9 lists the variable names which are variable through the RS-232 interface and their corresponding button sequences.

RS-232 VARIABLE NAMES

Var. Name	Button Sequence	Legal Values
MACHINE_ID	SETUP-MORE-COMM-ID	0000-9999
BAUD_RATE	SETUP-MORE-COMM-BAUD	300,1200,2300
CURR_TIME	SETUP-CLK-TIME	00:00-23:59
CURR_DATE	SETUP-CLK-DATE	01/01/00-12/31/99

TABLE 7.9

8.0 CALIBRATION

This section describes a method of performing a multi-point calibration of the Model 360U CO₂ Analyzer and a method of performing a zero-span check.

8.1 Required equipment and gas standards

Zero air must be free of CO₂ (less than 1.0 ppb of CO₂).

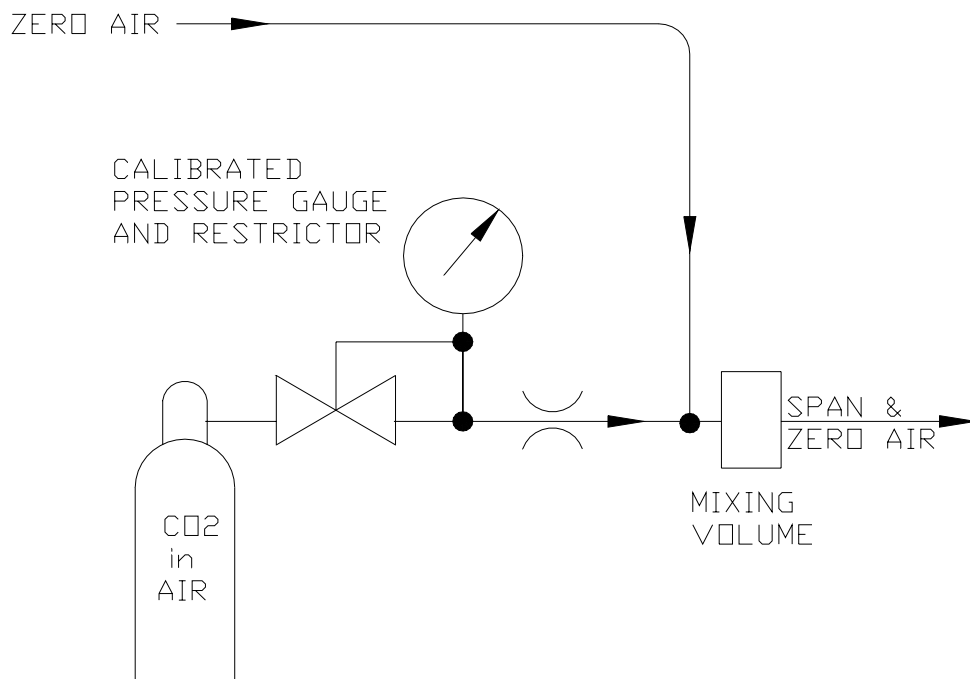
CAUTION

BE CAREFUL WHEN PULLING IN OUTSIDE AIR PARTICULARLY IF OUTSIDE HUMIDITY AND TEMPERATURE ARE HIGH. CONDENSATION MAY RESULT WHICH CAN LEAD TO UNSTABLE OPERATION, OR, AT WORST, WATER CONTAMINATION IN THE CELL.

Calibration gas concentrations should be generated from an NIST-traceable cylinder of CO₂ in air or nitrogen. Carrier air for transporting the CO₂ should be the same as the zero air. A suggested calibration gas generating system is shown in Figure 8.1.

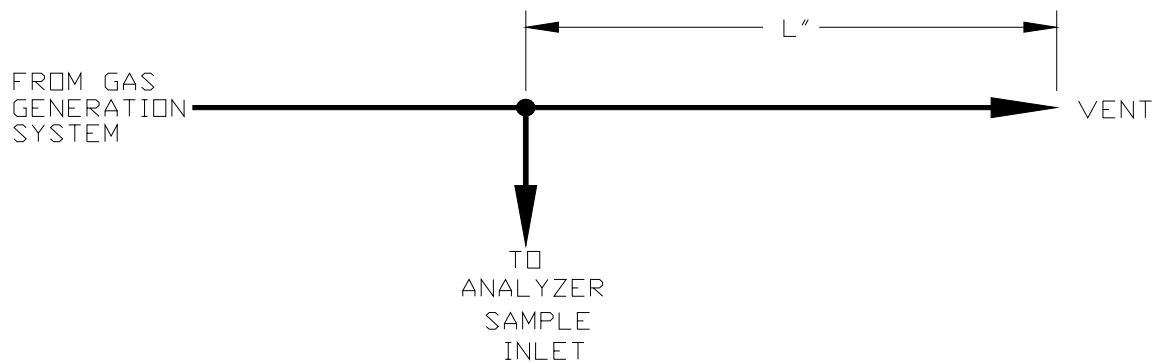
The materials in the calibration gas delivery system should be stainless steel, TFE and FEP (Teflon). The system must be clean.

The calibration gas delivery system (or manifold) must be properly vented to a suitable vent outside the analyzer area and near the analyzer inlet to avoid imposing a pressure or vacuum at the inlet. The recommended venting method is shown in Figure 8.2.



GAS GENERATION SYSTEM

FIGURE 8.1



INLET VENTING RECOMMENDATIONS

FIGURE 8.2

For minimum back-diffusion through the vent and for minimum back-pressure in the manifold, the following relationship should be met:

$$\frac{Q_v \times L}{Q_a \times D} = 500$$

Where Q_v is the vent flow in cc/min
 Q_a is the analyzer flow in cc/min
 L is the vent line length in inches
 D is the ID of the vent line in inches

For Q_v of 2500 cc/min
 Q_a of 2000 cc/min
 D of .188 inches
 L = approximately 72"

8.2 Multi-point calibration

Multi-point calibration requires seven approximately equally-spaced calibration points, including zero, using an NIST-traceable CO₂ source.

The calibration must be carried out:

1. After maintenance
2. Every three months (recommended)

NOTE

THE TEST GAS MUST BE INTRODUCED INTO THE ANALYZER THROUGH THE SAMPLE INLET PORT.

ALL FLOW MEASUREMENT DEVICES MUST BE CALIBRATED AGAINST AN NIST-TRACEABLE STANDARD SUCH AS A BUBBLE-FLOW-METER WHICH HAS BEEN CALIBRATED AGAINST AN NIST-TRACEABLE VOLUME STANDARD.

There are two acceptable methods of generating accurate CO₂ concentrations for calibrating the Model 360U.

One method uses a single cylinder of CO₂ in air and a means of accurately diluting the cylinder gas with zero air. This is illustrated in Figure 8.1.

Alternatively, several cylinders of CO₂ in air, of appropriate concentrations, may be used without dilution.

The cylinder concentrations must be traceable to NIST standards.

Flow correction for standard temperature and pressure (STP) is not required with either method. With dilution, the correction is self-canceling. With the multi-cylinder method, the correction is not applicable.

8.2.1 Procedure

1. Set the analyzer to the desired range.
2. Set the calibration system to deliver a flow of at least 1000 cc/min. more than the normal flow of the 360U. (See Section 8.1 and Figure 8.2 for vent flow calculation.)
3. Pre-calculate the calibrator flow to be sure that a CO₂ concentration of 80% of URL (upper range limit) can be produced with enough surplus flow to provide an adequate vent flow.
4. Connect the analyzer REC (recorder) terminals to a calibrated strip-chart recorder. For best accuracy, connect a DVM to the same terminals or to the DAS (Data Acquisition System) terminals

The standard output voltage of is 0-5.0 VDC.

If, in service, data is to be collected from a device (printer) connected to the RS-232 port, then the calibration data must be collected from the RS-232 port.

5. Set the calibrator to deliver zero air to the manifold.
6. Push "CAL" on the analyzer front panel.
7. Enter password. (If Enabled)
8. Wait 15 minutes for the analyzer to stabilize.
9. Push "ZERO" and "ENTR" on the front panel. The analyzer is now "zeroed."
10. Push "EXIT," "EXIT." (Return to sample mode.)
11. Record the DVM reading and the percentage chart reading or the RS-232 output.

12. Set the calibrator to produce 75% to 85% of the URL (upper range limit). This will be 800 ppb \pm 50 ppb on the 1000 ppb range.
13. Allow the analyzer to sample the CO₂ concentration.
14. Push "CAL"
15. Enter password. (If enabled)
16. Push "CONC"
17. Change the span value in the display to the calculated CO₂ concentration in the manifold in ppm units, and push "ENTR".
18. Wait 15 minutes for the analyzer to stabilize.
19. Push "SPAN" and "ENTER." The analyzer is now spanned. Record the calculated CO₂ concentration, the DVM reading and the percentage chart reading, or the RS-232 output.
20. Push "EXIT," "EXIT." The analyzer is now returned to the normal Sample mode.
21. Introduce at least five (5) more approximately evenly spaced CO₂ concentrations into the manifold to complete the manual calibration.
22. Record all calculated CO₂ concentrations, DVM reading and strip-chart recorder readings or RS-232 output readings.
23. Plot the calculated CO₂ concentrations (X-axis) versus output voltages and/or percentage chart readings (Y-axis).

Calculate the curve equations:

$$[\text{CO}_2] \text{ ppm} = (\text{Volts} - \mathbf{b}) / \mathbf{m}$$

where \mathbf{b} is the offset (should be within ± 0.05 volts of zero setting)
and \mathbf{m} is the slope (should be .098 to .102 based on 0-5V full scale)

or

$$[\text{CO}_2] = (\% \text{ chart} - \mathbf{b}) / \mathbf{m}$$

(\mathbf{b} should be within $\pm 1\%$ of chart and \mathbf{m} should be 1.96 to 2.04)

The correlation coefficient should be 0.998 or higher.

The analyzer is now calibrated. All CO₂ concentration data should be obtained by reading the analyzer output in volts or percentage of chart and converting to ppm from the appropriate equation or curve.

If poor correlation exists, check for

1. Flow calculation errors,
2. Concentration calculation errors,
3. Leaks in manifold,
4. Dirt in the manifold,
5. Proper manifold venting,
6. Zero air system.

If none of these help, see the TROUBLESHOOTING SECTION 10.0.

Record all the analyzer setup data from the display.

Range
DCPS
Box Temp
Wheel Temp
Bench Temp
Sample Temp
Pressure
MR ratio (Measure/reference ratio)
CO2 Reference
CO2 Measure

These data can be useful in future troubleshooting.

8.3 Zero/span checking

It is recommended that the Model 360U be checked daily for zero and span drift.

With the *Automatic Zero/Span Check* and *Remote Zero/Span Check* features of the Model 360, daily zero and span checks are easy.

For *Automatic Zero/Span Check* and *Remote Zero/Span Check* to be effective, it is necessary that the analyzer have the Zero/Span valve option. This option includes the two three-way stainless steel valves and requires user-supplied sources of zero air and span gas.

Operating instructions for *Automatic Zero/Span Check* and *Remote Zero/Span Check* are described in Sections 3.3 through 3.5.

9.0 ADJUSTMENTS

NOTE

**THE OPERATIONS OUTLINED IN THIS CHAPTER ARE
TO BE PERFORMED BY QUALIFIED MAINTENANCE
PERSONNEL ONLY!**



All adjustments to the Model 360U are easy to make. Pots and test points are readily accessible without removing any components.

Figure 1.2 is a plan view of the Model 360U CO₂ analyzer showing all the major components.

Figure 9.1 is an electrical diagram of Model 360U CO₂ Analyzer.

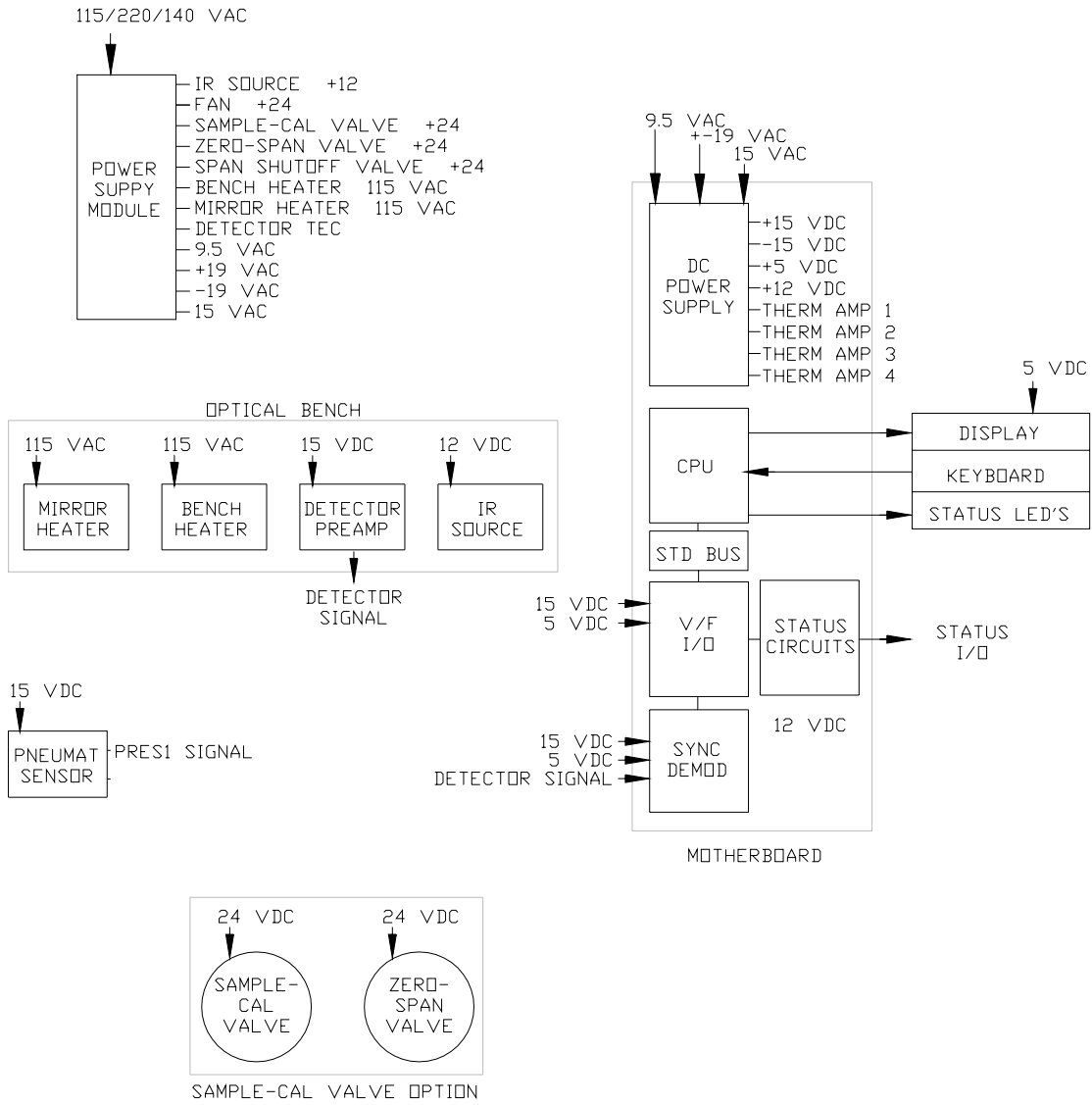
9.1 Power supply board adjustment

The power supply board provides +/-15v +12v and +5v DC power to the analyzer. Four temperature linearization circuits, for the analyzer main lamp, Sample temp, Box temp, and IZS carbon dioxide generator are also located on the power supply board.

Each circuit is a whetstone bridge with the measuring thermistor being one leg. A feedback circuit performs the required linearization. Zero adjust pots have been factory set and no field adjustment should be required.

9.1.1 Box temperature limits

The box temperature is measured by a thermistor located on the motherboard. The box temp is not controlled in the Model 360. The temperature is measured and displayed as a TEST function on the front panel (see Section 5.1). The alarm limits can be set via an RS-232 port command.



M360U ELECTRICAL BLOCK DIAGRAM

FIGURE 9.1

9.2 A/D - D/A Calibration procedure

Due to the stability of modern electronics, this procedure should not have to be performed more than once a year or whenever a major sub-assembly is exchanged or whenever analog output voltage range is changed .

To calibrate the voltage output, do the following: 4 - 20 mA current output calibration procedure should follow after voltage calibration.

1. Press SETUP-MORE-DIAG.
2. Enter Diagnostic password and press NEXT until D/A CALIBRATION appears in the display and press ENTR.
3. Press ADC to perform the A/D Cal.
4. The M360U display will read "ADJUST ZERO:A/D=xx.x MV." Put the probes of a calibrated voltmeter between the two Recorder Out pins at the instrument's rear panel (See Figure 1.3)
5. The value displayed by the voltmeter should be close(± 20 mV) to the value on the M360U display. If they are not close then the V/F card has probably been configured improperly.
6. Adjust the Zero pot (R27) on the V/F card until the value on the M360U display matches the value on the voltmeter to within ± 2 mV. *Note that when adjusting R27, the value on the M360U display will change, the value on the voltmeter will remain constant.*
7. Press ENTR.
8. The M360U display will now read "ADJUST GAIN:A/D=xx.x MV."
9. Adjust the Span pot (R31) on the V/F card until the value on the M360U display matches the value on the voltmeter to within ± 2 mV.
10. Press ENTR.
11. The ADC is now calibrated and the M360U will automatically calibrate all the DAC's. This process takes only a few seconds
12. Press EXIT 4 times to return to the sample menu.

To calibrate the 4-20 mA current output , do the following:

Verify 5 volt output DIP switch setting (refer to Table 10.4) for 4-20 mA output, since the input voltage of the 4-20 mA IC is configured for 0 - 5 volt range, before proceeding following procedure.

1. Connect the 200 - 450 ohm resistor to the 4-20 mA recorder output (refer to figure 1.3). Connect in series the DC current meter between the resistor and other terminal of the recorder output with proper polarity.
2. Press SETUP-DIAG-ENTR and scroll down to the D/A CALIBRATION diagnostic mode, press ENTR to start the procedure. Press CFG and scroll by pressing NEXT to select current output channel (1), press SET-CURR-ENTR to define current output channel. Press EXIT. Now channel 1 is defined as current output.
3. Press CAL to start the current output calibration. The M360U display will read "CAL CONC_OUT_1,CURR,ZERO", where CURR means current output and ZERO means zero analog output calibration. Press UP (UP10, U100) or DOWN (DN10, D100) buttons on the front panel until the current meter displays 4.0 mA (± 0.1 mA). When the current meter shows a stable 4.0 ± 0.1 mA, press ENTR.
4. The M360U display will now show "CAL CONC_OUT_1, CURR, GAIN". As before, press the up/down buttons on the M360U front panel until the current meter reads 20.0 ± 0.1 mA.
5. When completed press EXIT to return to upper level menus.
6. Verify that the analog output is correct by performing SETUP-DIAG-ANALOG OUTPUT. The current meter should read 4, 7.2, 10.4, 13.6, 16.8, and 20 mA accordingly. See Section 8.3.4.2 for additional current output measurement methods.

9.3 Dark current signal adjust procedure

The detector dark current changes little as the detector ages. Therefore this procedure should not need to be performed more than once per year or whenever a major sub-assembly is changed To calibrate the dark current signal, press **SETUP-MORE-DIAG-DARK-CAL** and the analyzer will automatically do the following:

1. Disconnect the detector output from the processing electronics.
2. Wait 2 minutes for electronics to stabilize at the dark value.
3. Average CO2 MEAS and CO2 REF reading for 1 minute.

4. Reconnect the detector output to the processing electronics to the processing electronics.

The average CO2 MEAS and CO2 REF dark reading are stored as offsets which are subtracted from all future CO2 detector readings.

To view the current dark offset, press **SETUP-MORE-DARK-VIEW**. Press **EXIT** when finished. No password is required to view the dark offset, only to change it.

9.4 Output voltage range changes

Output voltage ranges are set by DIP Switch settings on the V/F board. To change the range for the analog outputs:

1. Turn off instrument power. Remove the instrument cover. Locate the V/F board near the top of the drawing using Figure 1.2.
2. Locate switches S1, S2, and S3 along the top edge of the card. Select the desired range by setting the switches as shown in Table 9.1, below.

V/F BOARD SWITCH SETTINGS - RANGES FOR ANALOG OUTPUT

Switch	100 mV Full Scale	1 V Full Scale	5 V Full Scale	10 V Full Scale
S1 (Recorder Output)	1, 6	1, 5	1, 4	1, 3
S2 (DAS Output)	1, 6	1, 5	1, 4	1, 3
S3 (Test Output)	1, 6, 7	1, 5, 7	1, 4, 7	1, 3, 7

TABLE 9.1

NOTE

**TO ADJUST ANALOG RECORDER OFFSET,
SEE SECTION 4.7.**

9.5 Pressure readout adjustment

The pressure sensor consists of a pressure transducer.

This pressures is filtered to produce the front panel readings. Several minutes may be required for a steady reading if observing the TEST functions.

1. Check pressure:

- a. Remove the 1/4" fitting from Sample and exhaust fittings on the rear panel.
- b. Check the readings of PRES on the TEST functions.
- c. Check if the pressure readings are close to the current absolute ambient pressure (typical value at sea level is 29.9 in-Hg). Notice that it must be absolute pressure reading.

9.6 DC power supply

Overall performance of the DC power supply may be checked by observing the value displayed during test DCPS. If this value, a composite of the five (5) regulator outputs, deviates by more than 10% from the value recorded in Table 3.2 of this manual under Test Values, the outputs of the individual regulators should be measured.

Test points 1, 2, 3 and 4 provide connection to the temperature outputs on drawing no. 00016 in Appendix C.

9.7 CPU

If the display is operating and the green sample light is on, the CPU should be operating. If not, check for +5v to the CPU. Refer to Section 10.6.4 Checking DC power supply.

10.0 TROUBLESHOOTING

NOTE

THE OPERATIONS OUTLINED IN THIS CHAPTER ARE TO BE PERFORMED BY QUALIFIED MAINTENANCE PERSONNEL ONLY!



CAUTION

DO NOT DISCONNECT CPU OR OTHER DIGITAL CARDS WHILE UNDER POWER.

10.1 Overview

The Model 360U has been designed to rapidly detect possible problems and allow their quick evaluation and repair. During operation, the analyzer continuously performs self-check diagnostics and provides the ability to monitor the key operating parameters of the instrument without disturbing monitoring operations. These capabilities will usually allow the quick isolation and resolution of a problem.

A systematic approach to troubleshooting will generally consist of the following five steps, performed in order:

1. Confirm the proper operation of fundamental instrument sub-systems (Power Supplies, CPU, Display).
2. Note any warning messages and take corrective action as required.
3. Examine the values of *ALL* TEST functions and compare to factory values. Note any major deviations from the factory values and take correction action as required;
4. Address any dynamic (Sample related) problems.
5. If assistance is required, fill out a Warranty/Repair Questionnaire (Section 10.7) and fax or e-mail it to Teledyne API Customer Service.

The following sections provide a guide for performing each of these steps. Figure 1.2 in this manual shows the general layout of components and sub-assemblies in the analyzer and can be referenced in performing the checks described in the following sections.

10.2 Troubleshooting fundamental analyzer operation

When the analyzer is turned on, several actions will normally occur which indicate the proper functioning of basic instrument sub-systems. These actions are:

1. The green sample light on the front panel should turn on (or blink).
2. The Display should energize and display a log-on message followed by a standard "Sample" display (See Fig. 2.2 for illustration of a normal display).

If these actions all occur, it is probable that the analyzer's power supplies, CPU, and display are working properly.

If any of these actions fail to occur, power and/or CPU operation should be checked as follows:

10.2.1 Checking the power sub-systems

WARNING

HAZARDOUS VOLTAGES EXIST WITHIN THE INSTRUMENT CHASSIS - USE CAUTION!



1. Check incoming line power for proper voltage and frequency.
2. Check the Circuit breaker on the analyzer's rear panel.
3. Check the 3-wire safety power-input plug on the analyzer's rear panel.
4. Check for proper internal AC power by confirming that the Red (right-most) LED on the Power Supply Module is lit. If this LED is not lit, replace the fuse at the bottom center of the power supply module.
5. Check for proper DC Voltages by measuring for the following voltages on the V/F Board:

- +5V between TP4 and TP5
- +5V between TP1 and TP3
- 15V between TP2 and TP3

If any of these voltages are incorrect, check the DC Power Supply as described in Section 10.6.4.

10.2.2 Checking the CPU and display

When the analyzer is turned on, the front panel display should energize and the green "Sample" LED should light. If proper DC power is present (see Section 10.2.1), the absence of these actions will usually indicate either a CPU or Display failure. To determine which module is defective, perform the following procedure:

1. Turn off power.
2. Remove the ribbon cable from the CPU board to the keyboard.
3. Turn Power on.
4. A cursor character should appear in the upper left corner of the display. If it does not, the display is defective and should be replaced. If the cursor does appear, it is probable that the CPU is faulty.

10.2.3 Checking the keyboard

During normal analyzer operation, depressing the right most key of the keyboard should cause a change of display modes. If it does not, check:

- Cable connections;
- CPU and Display operation (see Section 10.2.2)

If these checks are satisfactory, it is probable that the keyboard is defective and should be replaced.

10.3 Troubleshooting using warning messages

The most common and/or serious instrument failures will result in a warning message (or messages) being displayed on the front panel. Table 10-1 lists the warning messages which the analyzer may display, along with their meaning and the recommended corrective action. It should be noted that if multiple (more than 2 or 3) warning messages occur at the same time, it is often an indication that some fundamental analyzer subsystem (power supply, V/F board, CPU) has failed rather than an indication of the multiple failures referenced by the warnings. In this situation, it is recommended that proper operation of power supplies (see Section 10.6.4) and the V/F Board (see Section 10.6.3) be confirmed before addressing the specific warning messages.

WARNING MESSAGES

Warning Message	Meaning	Corrective Action
SOURCE WARNING	The CO2 REF value is greater than 5000 mV or less than 500 mV	Check and adjust the Sync Demodulator and optical alignment as described in Section 10.6.6 and 10.6.8
SYNC ERROR	No modulation is present on the output of the IR detector.	Check IR source, IR detector/pre-amp, and Opto interrupter
BENCH HEAT SHUTDOWN	Temperature control of the Optical bench cannot be maintained at its 48°C set point	Check Optical Bench heater and thermistor as described in Section 9.10
SAMPLE PRESSURE WARNING	The Sample Pressure is less than 15"Hg or is greater than 35"Hg	Check for pressure transducer problems as described in Sect 10.6.5 and Sect 10.6.1
BOX TEMP WARNING	The inside chassis temp is less than 10°C or is greater than 50°C	See Section 10.6.2
SAMPLE TEMP WARNING	The Sample Temperature is less than 10°C or is greater than 50°C	See Section 10.6.2
CANNOT DYN ZERO	An offset of more than ±5 ppm would be required to Zero adjust the analyzer	See Section 10.5.5
CANNOT DYN SPAN	A slope of less than 0.5 or greater than 2.0 would be required to Span adjust the analyzer	See Section 10.5.6
V/F NOT INSTALLED	The CPU is unable to communicate with the V/F Board	Check and re-seat CPU and V/F board. See Sect. 10.6.3
SYSTEM RESET	A power Off-On cycle has occurred	None required
RAM INITIALIZED	Dynamic memory has been re-initialized in response to the installation of a new PROM or memory chip	None required

TABLE 10.1

10.4 Troubleshooting using test function values

The Model 360U provides the capability to display, on operator demand, the values of Test Functions which allow the observation of key analyzer operating parameters. These Test Functions can be accessed by depressing the TEST Button on the instrument's front panel, with each depression of the button causing the next test function to be displayed. By comparing the values of Test Functions to acceptable operating limits, it is possible to quickly isolate and correct most problems.

NOTE

IF THE VALUE OF ANY TEST FUNCTION IS DISPLAYED AS "XXXX", THIS INDICATES THAT THE READING IS OFF SCALE OR OTHERWISE NON-VALID.

Table 10-2 provides a list of available Test Functions along with their meaning, their range of acceptable values, and the recommended corrective actions if the value is not in the acceptable range. Additionally, Table 1-1 in this manual provides a list of the values of all Test Functions at the time the analyzer left the factory.

TEST FUNCTION VALUES

Test Function	Meaning	Acceptable Values	Corrective Action for Unacceptable Values
RANGE	The Current Full Scale Range Setting of the analyzer's analog outputs	Any	None required
CO2 MEAS	The most recent detector reading taken in Measure mode	2000-4800 mV	Check and adjust IR source and Sync Demodulator and optical alignment as described in Sect. 10.6.6 and 10.6.8
CO2 REF	The most recent detector reading taken in Reference mode	2000-4800 mV	Check and adjust IR source and Sync Demodulator and optical alignment as described in Sect. 10.6.6 and 10.6.8
MR RATIO	The ratio of the CO2 MEAS value to CO2 REF value	2.50-1.50	Check CO2 REF and CO2 MEAS values as described above.
PRES	The absolute pressure of the sample gas in the absorption cell	0"-1.0" Hg below ambient pressure	Check for pneumatic system problems. See Sect. 10.6.1. Check for pressure transducer problems. See Sect. 10.6.5
SAMPLE TEMP	The temperature of the sample gas in the absorption cell	48°-50° C (After warm-up)	See Section 10.6.2
BENCH TEMP	The temperature of the Optical Bench	48°C (After warm-up)	See Section 10.6.2
WHEEL TEMP	The temperature of the Gas Filter Wheel	68°C (After warm-up)	See Section 10.6.2
BOX TEMP	The temperature inside the analyzer chassis	up to 10°C above ambient	See Section 10.6.2

DCPS	DC Power Supply reference - A composite of all voltages provided by the DC Power Supply	2500 ±200 mV	See Section 10.6.4
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TABLE 10.2

10.5 Troubleshooting dynamic problems

Dynamic problems (i.e. problems which only manifest themselves when the analyzer is monitoring sample gas) can be the most difficult and time consuming to isolate and resolve. Additionally, analyzer behavior which appears to be a dynamic problem is often a symptom of a seemingly unrelated static problem. For these reasons, it is recommended that dynamic problems not be addressed until all static problems and warning conditions, as described in the preceding sections, have been isolated and resolved.

If all the checks described in the preceding sections have been successfully performed, the following will provide an itemization of the most common dynamic problems with recommended troubleshooting checks and corrective actions:

10.5.1 Noisy or unstable readings at zero

1. Check for leaks in the pneumatic system as described in Section 11.3.
2. Confirm that the Zero gas is free of Carbon dioxide.
3. Check for a dirty particulate filter and replace as necessary as described in Section 11.2.
4. Check for dirty Sample Cell and/or pneumatic lines. Clean as necessary as described in Section 11.4

10.5.2 Noisy, unstable, or non-linear span readings

1. Check for leaks in the pneumatic systems as described in Section 11.3.
2. Check for a dirty particulate filter and replace as necessary as described in Section 11.2.
3. Check for dirty pneumatic system components and clean or replace as necessary as described in Section 11.4.
4. Check for proper adjustment of DAC and ADC electronics by performing the adjustment procedure in Section 9.2.

5. Confirm the Sample Temperature and Sample Pressure readings are correct. Check and adjust as required.

10.5.3 Slow response to changes in concentration

1. Check for dirty pneumatic components and clean or replace as necessary as described in Section 11.4.
2. Check for pneumatic leaks as described in Section 11.3.
4. Check for improper materials in the inlet manifold.
5. Check for inadequate sample flow.

10.5.4 Analog outputs do not agree with front panel readings

1. Confirm that the DAC offset (SETUP-MISC-D/A-OFFS) is set to zero.
2. Perform a DAC/ADC adjustment and Dark Signal adjustment by following the procedure described in Sections 9.2 and 9.3.

10.5.5 Cannot zero or cannot dynamic zero

1. Check for leaks in the pneumatic system as described in Section 11.3.
2. Confirm that the Zero gas is free of Carbon Dioxide.
3. Check for a dirty particulate filter and replace as necessary as described in Section 11.1.
4. Check for inadequate sample flow.

10.5.6 Cannot span or cannot dynamic span

1. Check for leaks in the pneumatic systems as described in Section 11.3.
2. Check for a dirty particulate filter and replace as necessary as described in Section 11.2.
3. Check for proper adjustment of DAC and ADC electronics by performing the adjustment procedure in Section 9.2
4. Confirm the Sample Temperature and Sample Pressure readings are correct. Check and adjust as required.

10.6 Troubleshooting individual sub-assemblies and components

The following sections provide troubleshooting/check-out methods for the specific sub-assemblies and components of the analyzer.

10.6.1 Troubleshooting temperature problems

The Model 360U has been designed to operate at ambient temperatures between 10°C and 40°C. As a first step in troubleshooting temperature problems, confirm the ambient temperature is within this range and that the air inlet slots on the sides of the cover and the fan exhaust on the rear panel are not obstructed.

The instrument monitors four temperatures:

- Sample Temperature
- Inside Chassis Temperature
- Optical Bench Temperature
- Gas Filter Wheel Temperature

and controls the temperatures of two components by heating:

- Optical Bench
- Gas Filter Wheel

If any of the temperature readings appear to be incorrect, check for proper thermistor operation by measuring the resistance of the thermistor(s). This resistance should be in the range of 7.6K ohms to 95 ohms. If it is not, the thermistor is defective and should be replaced. Points for measuring thermistor resistance are as follows:

Sample Temperature:

Unplug the connector at Motherboard J2 and measure across the leads of the cable.

Optical Bench Temperature:

Unplug the connector at Motherboard J4 and measure across the leads of the cable.

Gas Filter Wheel Temperature:

Unplug the connector at Motherboard J5 and measure across the leads of the cable.

Box (Chassis) Temperature:

Turn the analyzer off and remove the DC Power Supply Board. Measure across Motherboard J21 pins A30 and C30.

If thermistor resistance(s) are within the proper range, check the temperature linearization circuits on the DC Power Supply Board as described in Section 10.6.4.

If temperature sensor readings appear accurate but control temperatures are not being maintained at their proper value, check the operation of the heaters as follows:

1. Observe the indicator LED's on the Power Supply Module and confirm that the red (right-most) LED is lit, and that the "CEL HTR" LED is lit or cycling (turning off and on). If these indicators are not correct, it is probably that the Power Supply Module, or the V/F Board is at fault. Check as described in Sections 10.2 and 10.6.3.
2. Unplug the heater element from Power Supply Module and confirm that 115 VAC is present. If 115 VAC is present, the heater element has failed and should be replaced.

WARNING

HAZARDOUS VOLTAGES PRESENT - USE CAUTION!



10.6.2 Checking the V/F card

A schematic and physical diagram of the V/F card are shown on Drawings 514 and 515 in Appendix C. The V/F is a multi-function I/O card which connects to the microprocessor via a STD Bus interface, and acts as the primary I/O interface between the microprocessor and the rest of the analyzer. All functions of the board are performed under control of the microprocessor.

Proper operation of the V/F board can be confirmed by performing an ADC calibration procedure as described in Section 9.2. If this calibration procedure can be performed correctly, it is highly probable that the V/F card is functioning properly. If the V/F does not function properly, check the following:

1. Confirm the presence of appropriate power by checking for:
 - +5V between TP 4 and TP 5
 - +15V at TP 1 and TP 3
 - -15V at TP 2 and TP 3

If any of these voltages are incorrect, check the DC Power Supply as described in Section 10.6.4.

2. Confirm that all jumpers and switches on the V/F board are set properly, as follows:

V/F BOARD JUMPERS - FACTORY SETTINGS

Factory Set Jumpers	
Jumper	Setting
JP1	1-2
JP2	1-2
B12	3-4
B14	ON
B15	Set to match input line frequency

TABLE 10.3

V/F BOARD SWITCH SETTINGS - RANGES FOR ANALOG OUTPUT

User Set Switches				
Switch	100 mV Full Scale	1 V Full Scale	5 V Full Scale	10 V Full Scale
S1 (Recorder Output)	1, 6	1, 5	1, 4	1, 3
S2 (DAS Output)	1, 6	1, 5	1, 4	1, 3
S3 (Test Output)	1, 6, 7	1, 5, 7	1, 4, 7	1, 3, 7
S4 (Spare)	1, 6, 7	1, 5, 7	1, 4, 7	1, 3, 7

TABLE 10.4

3. If Voltages and Jumper settings are correct, the V/F card is faulty and should be replaced.

The primary functions of the board can be divided into three areas:

- Channels of Multiplexed Analog input to an Analog to Digital converter
- independent Digital to Analog converters
- Digital I/O Lines configured as 24 outputs and 8 inputs

The following sections describe each of these functional areas:

10.6.2.1 Analog Inputs

16 Analog channels (0-5 VDC) are multiplexed under microprocessor control by IC U26 and transmitted via buffer amp U29 to the V/F converter section of the board for A/D conversion.

Analog to Digital (A/D) conversion is accomplished by performing a Voltage to Frequency (V/F) conversion on the input signal at IC U17 and running the frequency output to a counter comprised of IC's U20, U21, U22.

The full scale digital output of the counter section is 80,000 counts, giving an A/D resolution of 1 part in 80,000.

The combination of V/F converter and counter inherently provides an integrating Analog to Digital conversion. The time base for this integration is controlled by the microprocessor using the clock oscillator, U36. Jumper B15 allows the selection of either a 4.0 MHz or 4.8 MHz frequency to minimize electrical pickup at the operating line frequency. The time duration of integration is selectable over the range of 67 msec to 2.067 seconds. In the Model 360U an integrate period of 133 mseconds is used for reading the photodetector outputs, a 133 msec integrate period is used for all other signals.

Pots R27 and R31 provide offset and gain adjust respectively to the analog input of the V/F converter, allowing the A/D section to be adjusted to match an external voltage standard.

10.6.2.2 Digital to Analog Converters

Four Independent Digital to Analog Converters (DAC's) are contained in IC's U10 and U11 and are used to generate the instrument's analog outputs. These DAC's have 12 bit resolution and are fully buffered by OpAmps at U8 and U9. The outputs of the DAC's are jumper selectable for full scale range at jumpers B6, B7, B8 and B9. The Full Scale Ranges supported are:

- 0-100 mV
- 0-1 V
- 0-5 V
- 0-10 V

In the M360U the use of these four DAC's is:

DAC CHANNEL	SIGNAL
0	Recorder Analog Output
1	DAS Analog Output
2	Spare
3	Test Function Analog Output

The DAC's are operated in bipolar mode allowing a "live zero" on all output. In addition, DAC's 0 and 1 (Recorder and DAS) physically provide a Full Scale of 120% of the nominal selected value with the microprocessor providing pre-scaling to achieve the nominal value. This combination provides 20% over-range capability. The microprocessor is also used to adjust for offset and gain needed to match DAC outputs to external voltage standards, and no on board adjustments are needed or provided for this function.

The outputs of all DAC's are "looped-back" to Analog input (via the Mother Board) channels. This loop back allows for automatic microprocessor checking of A/D

10.6.2.3 Digital I/O lines

32 Digital Lines are used to provide the primary means for the microprocessor to control various analyzer functions(valves, heaters, etc.) and to send and receive status conditions to/from external equipment. These lines are configured as 8 digital inputs and 24 digital outputs. The convention for all Digital I/O Lines is High (+5V)-True, Low (0V)-False.

10.6.3 Checking the DC power supply board

A schematic and physical diagram of the DC Power Supply Board are shown on Drawings 015 and 016 in Appendix B.

The overall performance of the DC Power Supply Board can be checked by observing the value of the DCPS test functions. If this value, a composite of five regulator value recorded in Table 1-1 of this manual under Test Values, the outputs of the individual regulators should be checked by measuring for the following voltages:

1. Remove Plugs J8, J6, and J13 from the front of the Power Supply Module. Verify that the following voltages are present:
 - +11.5VDC between J8 pins 2 and 4
 - +24VDC between J6 pins 12 and 13
 - 9.5VAC between J13 pins 4 and 5
 - 15VAC between J13 pins 3 and 2
 - 38VAC between J13 pins 6 and 7

If any of these voltages is not present, the Power Supply Module is defective and should be replaced.

2. Confirm that the following voltages are present on the V/F Board:
 - +5V between V/F TP 4 and V/F TP 5
 - +15V between V/F TP 1 and V/F TP 3
 - -15V between V/F TP 2 and V/F TP 3
 - +12V between Mother Board Pad J13,6 and J13,7

If any of these voltages is incorrect, it is probable that the DC Power Supply Board is faulty and should be replaced.

Four Temperature linearization circuits are contained on the DC Power Supply board. The outputs of these circuits can be checked by measuring the voltages at test points on the board as follows:

TP1 Sample Temp	$30^{\circ}\text{C}=2.5\text{ V}, \pm.125\text{ V}/^{\circ}\text{C}$
TP2 Optical Bench	$50^{\circ}\text{C}=2.5\text{ V}, \pm.125\text{ V}/^{\circ}\text{C}$
TP3 Filter Wheel Temp	$50^{\circ}\text{C}=2.5\text{ V}, \pm.125\text{ V}/^{\circ}\text{C}$
TP4 Chassis Temp	$20^{\circ}\text{C}=2.5\text{ V}, \pm.125\text{ V}/^{\circ}\text{C}$

If any of these voltages is incorrect, check thermistor operation as described in Section 10.6.2. If thermistors are operating correctly, it is probable the DC Power Supply Board is defective and should be replaced.

10.6.4 Checking the Synchronous Demodulator Board

A schematic and physical diagrams of the Synchronous Demodulator Board are shown in drawings 798 and 799 in Appendix C.

Proper operation of the Synchronous Demodulator can best be confirmed by performing the Electric Test Diagnostic as described in Section 5.2.4.

When activated, the Electric Test Diagnostic should produce a constant, stable analyzer output of approximately 500 ppm. If this stable output is produced it is probably that the Synchronous Demodulator is functioning properly.

If Electric Test does not produce a stable output, check the following:

1. Confirm proper operation of the V/F Board as described in Section 10.6.3.
2. Confirm that during Electric Test the values of the CO₂ MEAS and CO₂ REF test functions are between 2500mV and 4500mV. If they are not, adjust the signal levels by turning Pot R7 on the Synchronous Demodulator Board.

10.6.5 Checking the Opto Interrupter

Correct operation of the Opto Interrupter on the gas filter wheel can be confirmed by connecting an oscilloscope to U6, Pin 11 on the Sync Demodulator board and comparing the waveform to Figure 10.2. The waveform should be symmetrical and 5 Volts peak to peak.

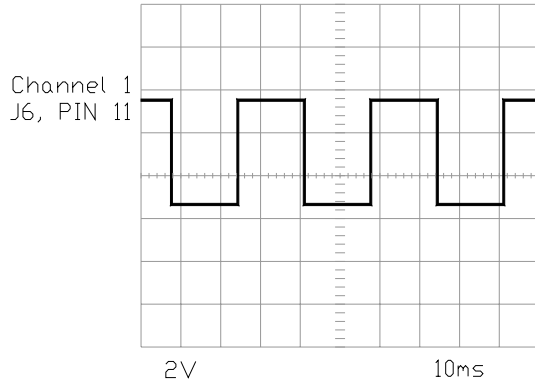


FIGURE 10.2 OPTO PICKUP WAVEFORM

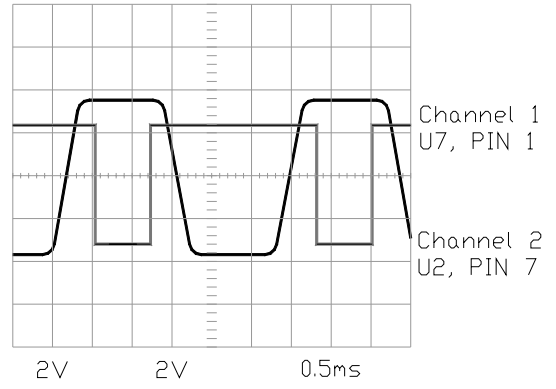


FIGURE 10.3 DETECTOR WAVEFORM

10.6.6 Checking Optical Alignment

The mirrors used in the optical system of the Model 360U are designed to have their alignment set permanently during the manufacturing process and no adjustment is normally needed. If the optical system is disassembled or if failure of any of the optical components is suspected, the instrument can be checked for proper optical alignment as follows:

1. Connect a source of zero air to the analyzer.
2. Allow the analyzer to warm-up for 60 minutes.
3. Confirm Optical System Energy through-put by:
 - a. Press the TST> or TST< button on the front panel until the CO₂ MEAS value is displayed.
 - b. Increase the gain of the Synchronous Demodulation by turning Pot R7 on the Sync Demodulator board clockwise. If a CO₂ MEAS value of 5000 mV can be obtained, energy throughput is acceptable.
 - c. Re-adjust Pot R7 on the Sync Demodulator Board to obtain a CO₂ MEAS reading of 4200 mV (± 200).
4. Connect an oscilloscope to U7-Pin 1. Sync the oscilloscope on this channel.
5. Confirm the wave form of the optical signal by attaching an oscilloscope to the Sync Demodulator board at U2 Pin 7. The oscilloscope trace should appear like those shown in Figure 10.3. In particular the wave form should be symmetrical and should have distinct flat regions at the top and bottom of the pulses.
6. If unable to achieve 4200 mV on CO₂ MEAS, then do the following:
7. Adjust source for maximum signal strength. Typically source has no effect on wave shape. (Not to exceed 27V peak to peak.)
8. Adjust input mirror as needed to create a wave shape with distinct flattening of the peaks and symmetrical "Knees" at the peaks. A smaller waveform with nice symmetry is preferable to a larger one which is asymmetrical.
9. With zero air in, verify an MR RATIO of 2.3 to 2.5 is desired. If the analyzer shows a significantly different value, slightly adjust the input mirror.
10. Adjust R7 for a CO₂ MEAS reading of 4200 ± 200 mV.

10.7 Warranty/repair questionnaire

Organization: _____
Contact: _____ Phone: _____
Address _____

Model 360U Serial Number: _____

Are there any warning messages? YES NO

If **YES**, please list: _____

Please record the following values:

TEST VALUES	
RANGE	_____ PPM/PPB
CO2 MEAS @ ZERO	_____ mV
CO2 REF @ ZERO	_____ mV
MR RATIO @ ZERO	_____
CO2 MEAS @ SPAN	_____ mV
CO2 REF @ SPAN	_____ mV
MR RATIO @ SPAN	_____
SAMPLE PRESS	_____ IN HG-A
SAMPLE TEMP	_____ °C
BENCH TEMP	_____ °C
WHEEL TEMP	_____ °C
BOX TEMP	_____ °C
DC POWER SUPPLY	_____ mV
TIME	_____ HH:MM:SS

CALIBRATION VALUES	
CO2 SPAN SETTING	_____ PPM/PPB
CO2 SLOPE	_____
CO2 OFFSET	_____

SETUP VALUES	
ELECTRIC TEST	_____ PPM
DARK MEAS	_____ mV
DARK REF	_____ mV

Has the unit been leak checked? YES NO

What are failure symptoms? _____

If possible, please include a portion of a strip chart pertaining to the problem. Circle pertinent data.

Do opto Interrupter and detector waveforms match those shown in Figures 10.2 and 10.3?
YES NO

Thank you for providing this information. Your assistance enables Teledyne API to respond faster to the problem that you are encountering.

Teledyne API Customer Service
Phone: (858) 657-9800 Toll Free:(800) 324-5190 FAX: (858) 657-9816
e-mail: customerservice@teledyne.com

11.0 ROUTINE MAINTENANCE

NOTE

THE OPERATIONS OUTLINED IN THIS CHAPTER ARE TO BE PERFORMED BY QUALIFIED MAINTENANCE PERSONNEL ONLY!



11.1 Model 360U maintenance schedule

The following are the recommended periodic maintenance items for the Teledyne API Model 360U CO₂ Analyzer:

Date Instrument Was Received: _____													
ITEM	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	RECOMMENDED ACTION
Particulate filter element													Replace weekly or as needed.
Zero Scrubber (Option)													Replace material monthly or as needed
Sample flow													Check for proper flow (800cc/min ±20%) annually.
Dark Cal													Perform annually as needed
Pneumatic lines													Examine and clean as necessary.
Leak Check													Leak Check after maintenance and at least annually.
Clean optical bench													As needed.

TABLE 11.1

11.2 Replacement of sample filter

1. Disconnect the source of sample gas from the analyzer. This will eliminate the possibility of sucking debris into the analyzer while changing the filter element.
2. Open the front panel and remove the transparent filter cover and knurled retaining ring.
3. Remove the Teflon hold-down O-ring.
4. Remove the old filter element and discard.
5. Install a new filter element in the filter cavity. Be careful with the element, it is fragile.
6. Replace the hold-down O-ring on top of the filter element.
7. Replace the filter top and re-tighten.
8. Leak check.
9. Re-connect sample gas.

11.3 Leak checking

There are two methods of leak checking.

11.3.1 Using a leak checker

Turn the power off. Connect the leak checker to the sample inlet of the Model 360U. Cap the exhaust of the analyzer. Set the leak checker to pressure mode.

CAUTION

DO NOT EXCEED 15 PSI OF PRESSURE.

Leave the checker on until 15 psi is achieved. Close the valve and ensure the pressure remains at 15 psi for at least 5 minutes. If pressure drops more than 1 psi, there is a leak and it must be repaired.

If there is a leak present, pressurize the Model 360U to 15 psi and put soap bubble solution on pneumatic assemblies until the leak is found.

CAUTION

BE CAREFUL USING THE BUBBLE SOLUTION. IF THERE IS NO INTERNAL PRESSURE, THE SOLUTION MAY ENTER AND CONTAMINATE THE CELL.

DO NOT ATTEMPT TO USE THE BUBBLE SOLUTION WHILE THE UNIT IS UNDER VACUUM. THIS MAY CAUSE DAMAGE TO THE ANALYZER.

USE ONLY BUBBLES, NOT LIQUID.

11.4 Changing the prom

1. Locate the CPU card by referring to Figure 1.2.
2. Remove the screws that hold the CPU card (SBC40 printed on the lever) top corner to the A/D - I/O card, then remove the card from the STD-BUS backplane.
3. Remove the two cables attached to the SBC40, taking note of the polarity.
4. Remove the card, laying it down on an insulating surface such that the card edge pins on the PCB are on the left. The PROM chip should be at the top center. The current chip should be labeled with something like "API CO2 A.6 - - -". Gently pry the chip from its socket and replace it with the new chip. Install the chip in the left end of the socket with the notch facing to the right. Make sure that all of the legs insert into the socket correctly.
5. Replace the CPU board and re-attach the connectors, making sure to observe the polarity.
6. Re-attach the CPU card to the STD-BUS.
7. Move the power switch to the "ON" position and observe the front panel display. As the analyzer goes through the setup the version number will be displayed on the front panel. It should read the same as the version number that was located on the top right corner of the label on the PROM.

8. Re-enter any non-default settings such as RANGE or ASEQ. Re-enter the CONC value in the CAL menu. Check all settings to make sure that expected setup parameters are present.
9. Re-calibrate the analyzer so that the default slope and intercept are overwritten with the correct values.

12.0 SPARE PARTS LISTS

12.1 Spare parts for CE Mark units

Note: Use of replacement parts other than those supplied by Teledyne API may result in non-compliance with European Standard EN 61010-1.

<u>PART NO.</u>	<u>DESCRIPTION</u>
00015	POWER SUPPLY BOARD
00276-0804	CPU BOARD
00329	THERMISTOR ASSY (885-071600)
00329-12	THERMISTOR ASSY: WHEEL
00329-11	THERMISTOR ASSY: BENCH
00514-03	V/F BOARD
00551-14	POWER SUPPLY MODULE (EU) - 230V/50Hz
00551-18	POWER SUPPLY MODULE (UK) - 230V/50Hz
00611-04	ASSY, STRIP HEATER
00611-05	ASSY, HEATER, WHEEL
01930	SAMPLE FILTER ASSY
00690-00	PADS
01930	KEYBOARD
00728	NEW DISPLAY
00798	SYNC DEMODULATOR BOARD
0261803	ASSY, OPTICAL BENCH
0095308	PREAMP/DETECTOR ASSEMBLY
00969	FILTER, TFE, 47 MM, QTY 100
00969-01	FILTER, TFE, 47 MM, QTY 25
00982	ASSY, SYNCHRONOUS MOTOR
02142	OPTO INTERRUPTER ASSEMBLY
03895	INSTRUCTION MANUAL FOR M360U
02607	FIELD MIRROR
01079	INPUT MIRROR
01080	OUTPUT MIRROR
01581	SOURCE ASSEMBLY (WITH ADAPTOR)
02606	OBJECTIVE MIRROR
01916-01	REAR PANEL BOARD, CE
01930	KEYBOARD, CE
01934-02	ASSY, SAMPLE THERMISTOR
CB004	FUSE, 3 AG 3 AMP 250V
00793	FAN
FL001	SINTERED FILTER (002-024900)
HW036	TFE THREAD TAPE (48 FT)
HW037	TIE, CABLE
OP009	WINDOW, SAPPHIRE
OR025	O-RING, SCRUBBER

OR030	O-RING, 2-141 V
OR034	O-RING, INPUT/OUTPUT MIRROR/DETECTOR
OR039	O-RING, WINDOW
SW006	OVERHEAT SW, CELL
02471	TUBING: 6', 1/8" CLR (TU1)
02472	TUBING: 6', 1/8" BLK (TU2)
02475	TUBING: 6', 1/4" TYGON (TU9)
VA002	SOLENOID, SS, 3-WAY, 24V
VA004	SOLENOID, SS, 2-WAY, 24V

12.2 Model 360U Expendables kit

<u>PART NO.</u>	<u>DESCRIPTION</u>
009600400	M360U 47 mm Filter Expendables Kit
Includes:	
009690100	Filter, TFE, 47 mm 5 um, Qty. 25

12.3 Model 360U Spare parts kit (for one unit)

<u>PART NO.</u>	<u>DESCRIPTION</u>
037620000	M360U Spares Kit for 1 Unit
Includes:	
015810000	Source Assembly (with Adapter)
KIT000109	Replacement, Opto Sensor

12.4 Model 360U Level 1 parts kit (for ten units)

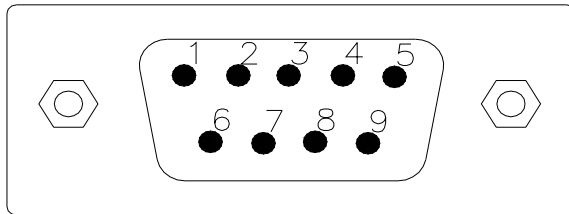
<u>PART NO.</u>	<u>DESCRIPTION</u>
037610000	M360U Level 1 Spare Parts Kit (for 10 units)
Includes:	
000941000	Orifice, 13 mil 1000 cc, Rx Cell
007930000	Assembly, Fan, PSM (FA0000004 ASSY)
009530800	Pre-amplifier/Detector Assembly
009820000	Motor, Synchronous
015810000	Source Assembly (with Adapter)

019340200 Thermistor Assembly: Sample TEE
KIT000109 Replacement, Opto Sensor

APPENDIX A Tips on connecting the Teledyne API analyzer RS-232 interface

Teledyne API analyzers use the RS-232 communications protocol to allow the instrument to be connected to a variety of computer-based equipment. RS-232 has been used for many years and as equipment has become more advanced, connections between various types of hardware have become increasingly difficult. Generally, every manufacturer observes the signal and timing requirements of the protocol very carefully. Problems arise when trying to specify connectors, and wiring diagrams that attach the analyzer to various devices.

The problem centers around two areas. First is the physical incompatibility of connectors. Second is the wiring of the connectors. This Note will attempt to provide some guidelines for connecting the Teledyne API analyzers to a variety of other equipment



Pin	Signal
1	Not Used
2	Transmit Data
3	Receive Data
4	Not Used
5	Signal Ground
6	Not Used
7	Data Set Ready (DSR)
8	Request to Send (RTS)
9	Not Used

RS-232 PIN ASSIGNMENTS
FIGURE A.1

Connectors:

There are a wide variety of connectors and cables that are specified to operate with the RS-232 protocol. This is because electronics have decreased in size over the years and connectors have been downsized to match the electronics.

Cables & Adapters come in 4 general types

1. Cables - cables are provided in various lengths from 6 to 50 feet. In most cases they have a male connector at one end and a female at the other. Variations on this are ones that provide both a cable and adapter. For example the cable provided with our analyzer adapts a female DB-9 to a male DB-25 connector. Most cables do not contain a Null modem.
2. Gender changers - convert a male connector to a female connector or vice versa. They do so WITHOUT changing the pin-to-pin wiring.

3. Adapters - these change from one type plug (DB-9) to another type plug (DB-25). They do so WITHOUT changing the wiring.
4. Null modems - here the connector changes the internal wiring so that DTE devices can become DCE or vice versa. The main internal change is swapping pin 2 and 3 so that data is transmitted and received on opposite pins.

NOTE

NULL MODEMS CAN ALSO COMBINE GENDER CHANGER OR ADAPTER FEATURES IN THE DESIGN. WHEN MAKING UP AN ADAPTER CABLE BE CAREFUL TO NOTE WHAT YOU ARE USING, ESPECIALLY WITH COMBINATION NULL MODEM-ADAPTER CONNECTORS.

Wiring:

The RS-232 is a point-to-point protocol and as such it specifies a two different wiring schemes depending on if you are originating the transmission or receiving the transmission. In the original spec, modems communicated with terminals and were wired as "Data Communications Equipment" or DCE. Terminals or printers received data from modems and thus were wired as "Data Terminal Equipment" or DTE. As technology has progressed it has become more ambiguous who was DCE and DTE. Teledyne API analyzers are wired as DTE (i.e. like a printer). As can be seen, this presents difficulties if you a hook

a printer to the instrument that is likewise wired as a printer. To help understand the different problems - 3 examples as shown below:

Example 1: Connecting the Teledyne API analyzer to an IBM-PC AT compatible computer.

In this case the PC is wired as DCE and the analyzer is wired as DTE therefore a null modem is not needed. The wiring is "straight through" i.e. pin 1 to pin 1, pin 2 to pin 2, etc. Therefore all you have to do here is adapt the connector on the analyzer (male DB-9) to whatever is on the PC. Make sure none of the adapters have null modems in them.

Example 2: Connecting the Teledyne API analyzer to a serial printer.

In this case both the analyzer and the printer are wired as DTE so a "Null Modem" will have to be inserted in the line to change the wiring to make the analyzer look like a modem (i.e. DCE). Make sure in using your adapters that ONLY ONE null modem

connector is used. Null modems can be purchased in DB-9 and DB-25 connectors at each end.

Example 3: Connecting the Teledyne API analyzer to a modem.

The modem is configured as Data Communications Equipment (DCE), and may have additional signal requirements to enable transmission. See modem troubleshooting section below.

NOTE

MODEMS ARE ESPECIALLY DIFFICULT BECAUSE THEY MAY HAVE PINS THAT NEED TO BE AT CERTAIN EIA RS-232 LEVELS BEFORE THE MODEM WILL TRANSMIT DATA. THE MOST COMMON REQUIREMENT IS THE READY TO SEND (RTS) SIGNAL MUST BE AT LOGIC HIGH (+5V TO +15V) BEFORE THE MODEM WILL TRANSMIT. THE TELEDYNE API ANALYZER SETS PIN 8 (RTS) TO 10 VOLTS TO ENABLE MODEM TRANSMISSION.

Troubleshooting the modem connection:

First: Disconnect the RS-232 cable from the analyzer and verify (use a DVM) that you are getting a signal on Pin 2 of the RS232 port on the analyzer. The signal will be between -5V and -15V with respect to signal ground (pin 5). If not, there is a problem with the CPU board or the cable. This is the transmit (TD) signal out of the analyzer. This should then be connected to TD input on the modem, normally Pin 2. If the analyzer is equipped with a DTE/DCE switch, you may need to change its setting so the signal is on Pin 2.

Second: Go to the cable connected to the modem/terminal and verify (use a DVM) that you are getting a -5V to -15V signal on Pin 3 of the cable. This pin should be connected to Pin 3 of the Teledyne API analyzer.

Third: (for modems) Check that the voltage level on Pin 8 of the analyzer is between +5V and +15V. This pin should be connected (through the cable) to Pin 4 of the modem.

Now set the baud rate of the analyzer to the speed required by the modem and it should work. If you are still experiencing problems, a cable adapter may be needed. Please contact the factory for assistance.

APPENDIX B Electrical drawing index

<u>Drawing Number</u>	<u>Title</u>
00015	Assembly, DC Power Supply PCA
00016	Schematic, DC Power Supply PCA
00514	Assembly, A/D - I/O Card PCA
00515	Schematic, A/D - I/O Card PCA
00532	Assembly, Power Supply Module PCA
00533	Schematic, Power Supply Module PCA
00551	Wiring Diagram, Power Supply Module
00798	Assembly, Sync Demodulator
00799	Schematic, Sync Demodulator
00866	Assembly, Mother Board
00867	Schematic, Mother Board
00874	Assembly, Pre-Amp/Bias
00875	Schematic, Pre-Amp/Bias
01916	Assembly, Rear Panel PCA (CE Mark Units Only)
01917	Schematic, Rear Panel PCA (CE Mark Units Only)
01930	Assembly, Keyboard PCA (CE Mark Units Only)
01931	Schematic, Keyboard PCA (CE Mark Units Only)
03747	Interconnect Diagram (CE Mark Units)