TRAINING MANUAL

MODEL 300E / T300
CARBON MONOXIDE ANALYZER
Also including the M300EU and M360E

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User Notes:

1. PRINCIPLE OF OPERATION

Measurement Method - Beer's Law

The basic principle by which the analyzer works is called Beer's Law. It defines the how light of a specific wavelength is absorbed by a particular gas molecule over a certain distance. The mathematical relationship between these three parameters is:

$$I = I_o \, e^{-\alpha Lc}$$

Where:

I_o is the intensity of the light if there was no absorption.

I is the intensity with absorption.

L is the absorption path, or the distance the light travels as it is being absorbed.

c is the concentration of the absorbing gas. In the case of the Model 300E, carbon monoxide (CO).

α is the absorption coefficient that tells how well CO absorbs light at the specific wavelength of interest.

Measurement Fundamentals

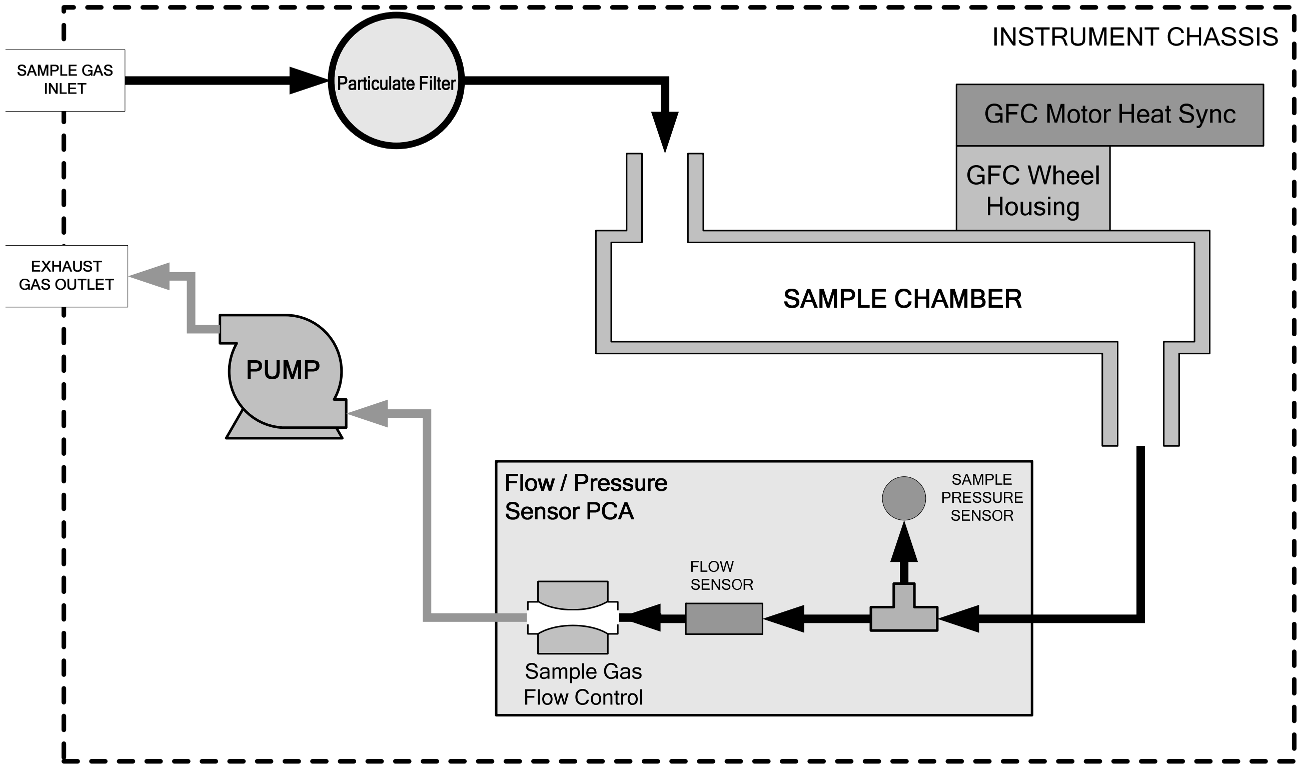
In the most basic terms, the Model 300E uses a high energy heated element to generate a beam of broad-band IR light with a known intensity (measured during Instrument calibration). This beam is directed through multi-pass cell filled with sample gas. The sample cell uses mirrors at each end to reflect the IR beam back and forth through the sample gas to generate a 14 meter absorption path. This length was chosen to give the analyzer maximum sensitivity to fluctuations in CO density.

Upon exiting the sample cell, the beam shines through a band-pass filter that allows only light at a wavelength of 4.7µm to pass. Finally, the beam strikes a solid-state photo-detector that converts the light signal into a modulated voltage signal representing the attenuated intensity of the beam.

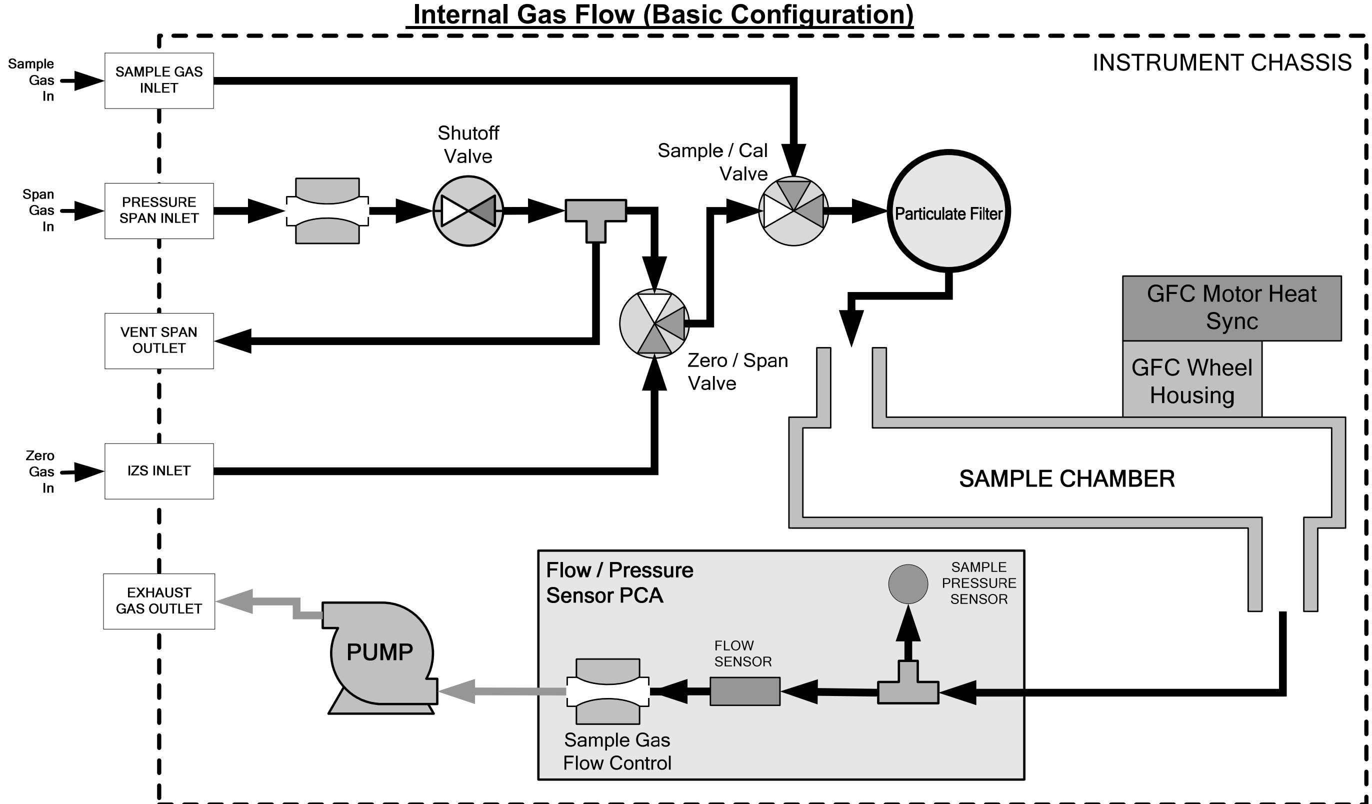
Unfortunately, several gases also absorb light at 4.7µm. Among these are water and carbon dioxide, both of which are much more common gases, compared to CO. To overcome the interfering effects of these, as well as other, gases the Model 300E adds another component to the IR Light path called a Gas Filter Correlation (GFC) Wheel.

2. PNUEMATICS AND SUB-ASSEMBLIES

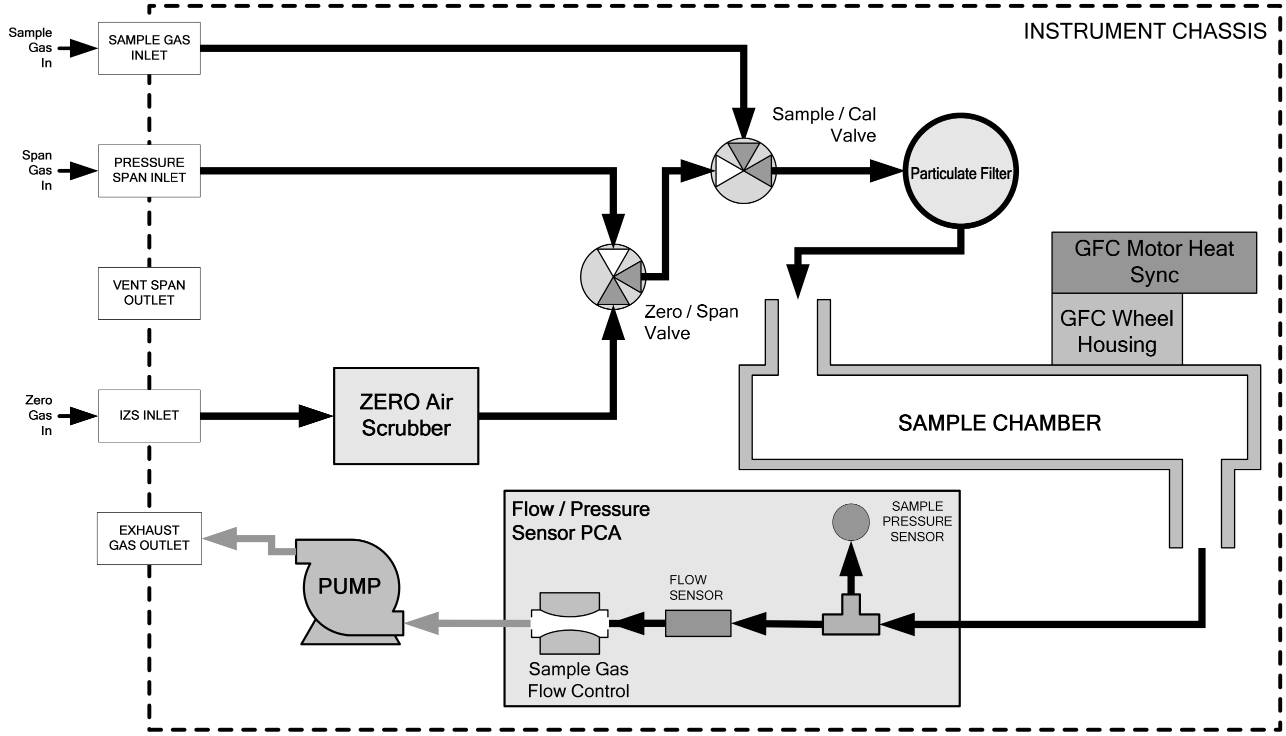
Pneumatic/Flow Diagrams



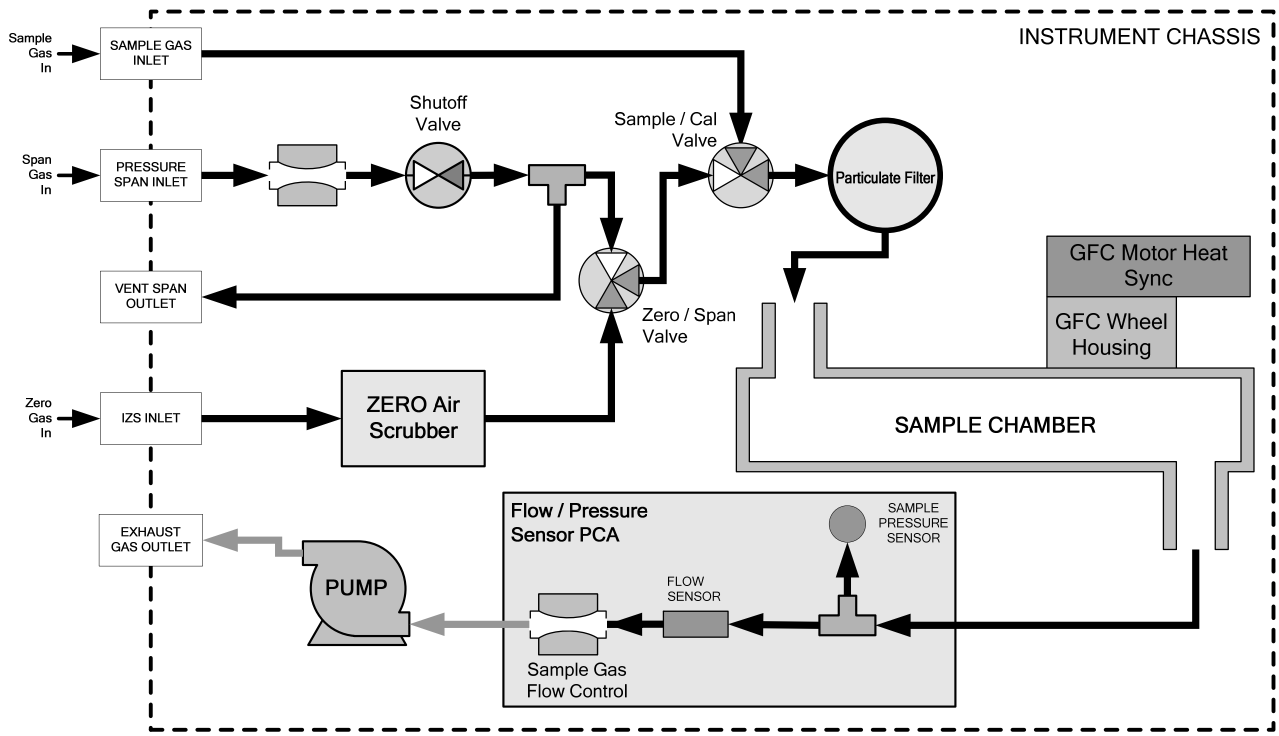
Internal Gas Flow (Basic Configuration)



OPT 50B – Zero/Span/Shutoff Valves



OPT 51B – Zero/Span Valves with Internal Zero Air Scrubber



OPT 51C – Zero/Span/Shutoff Valves with Internal Zero Air Scrubber

Optical Bench & GFC Wheel

Electronically. the Model 300E's optical bench, GFC wheel and associated components do more than simply measure the amount of CO is present in the Sample Chamber. A variety of other critical functions are performed here as well.

Sample Gas and GFC Temperature Control

Because the temperature of a gas affects its density and therefore the amount of light absorbed be that gas it is important to reduce the effect of fluctuations in ambient temperature on the Model 300E's measurement of CO. To accomplish this both the temperature of the Sample Chamber and the GFC Wheel are maintained at constant temperatures above their normal operating ranges.

Bench Temperature : To minimize the effects of ambient temperature variations on the sample measurement, the Sample Chamber is heated to 48°C (8 degrees above the maximum suggested ambient operating temperature for the analyzer). A strip heater attached to the underside of the chamber housing is the heat source. The temperature of the Sample Chamber is sensed by a thermistor, also attached to the Sample Chamber housing.

Wheel Temperature: To minimize the effects of temperature variations caused by the near proximity of the IR Source to the GFC Wheel on the gases contained in the wheel, it is also raised to a high temperature level. Because the IR Source itself is very hot, the set point for this heat circuit is 68°C. In this case a cartridge heater is implanted into the heat sync on the motor is the source. The temperature of the wheel/motor assembly is sensed by a thermistor also inserted into the heat sync.

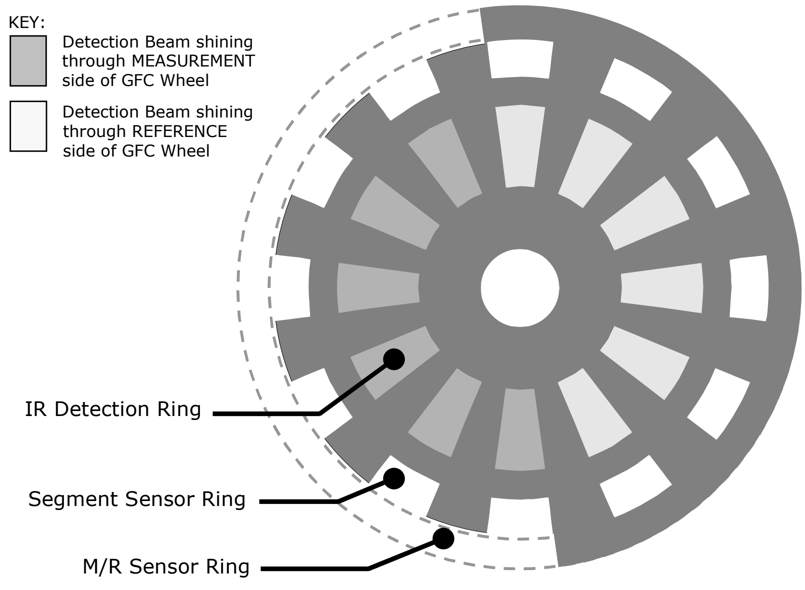
Both heaters operate off of the AC line voltage supplied to the instrument.

IR Source

The light used to detect CO in the Sample Chamber is generated by an element heated to approximately 1100°C producing infrared radiation across a broad band. This radiation is optically filtered after it has passed through the GFC Wheel and the Sample Chamber and just before it reaches the photo-detector to eliminate all black body radiation and other extraneous IR emitted by the various components of those components.

GFC Wheel

A synchronous AC motor turns the GFC Wheel motor. For analyzers operating on 60Hz line power this motor turns at 1800 rpm. For those operating on 50Hz line power the spin rate is 1500 rpm. The actual spin rate is unimportant within a large rate since a Phase Lock Loop circuit is used to generate timing pulses for signal processing In order to accurately interpret the fluctuations of the IR beam after it has passed through the Sample Gas, the GFC Wheel several other timing signals are produced by other photo emitters/detectors. These devices consist of a combination LED and detector mounted so that the light emitted by the LED shines through the same mask on the GFC Wheel that chops the IR beam.



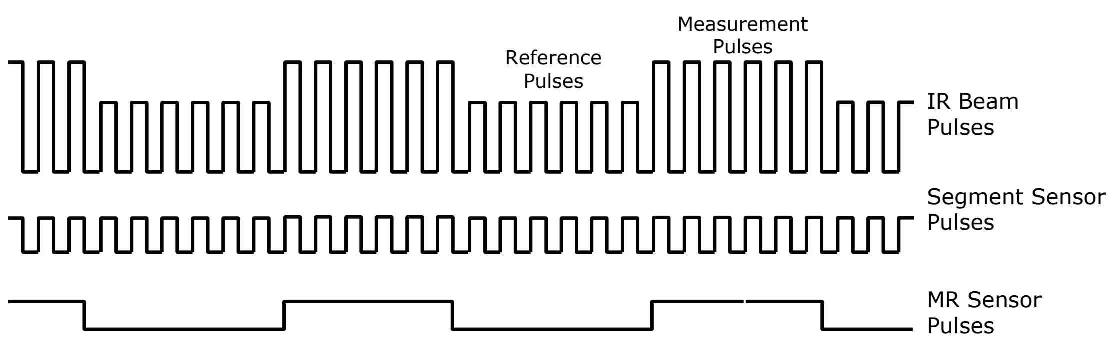
GFC Light Mask

M/R Sensor

The emitter/detector assembly that produces this signal shines through a portion of the mask that allows light to pass for half of a full revolution of the wheel. The resulting light signal tells the analyzer whether the IR beam is shining through the Measurement or the Reference side of the GFC Wheel.

Segment Sensor

This emitter/detector shines through a portion of the mask that is divided into the same number of segments as the portion of the mask through which the IR beam passes. It is used by the Synchronous / Demodulation circuitry of the analyzer to latch onto the most stable part of each Measurement and Reference IR pulse.



Segment Sensor and M/R Sensor Output

Schmidt Triggers: To ensure that the waveforms produced by the Segment Sensor and the M/R Sensor are properly shaped and clean, these signals are passed through a set of Schmidt Triggers circuits.

IR Photo-Detector

The IR beam is converted into an electrical signal by a cooled solid-state photo-conductive detector. The detector is composed of a narrow-band optical filter, a piece of lead-salt crystal whose electrical resistance changes with temperature, and a two-stage thermo-electric cooler.

When the analyzer is on, a constant electrical current is directed through the detector, The IR beam is focused onto the detector surface, raising its temperature and lowering its electrical resistance that results in a change in the voltage drop across the detector.

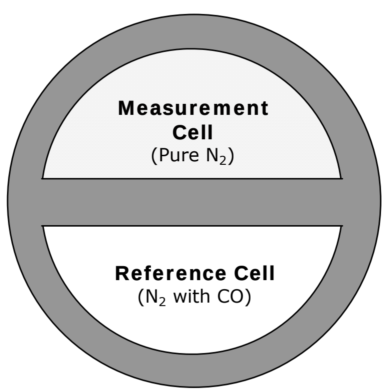
During those times that the IR beam is bright, the temperature of the detector is high; the resistance of the detector is correspondingly low and its output voltage output is high. During those times when the IR beam intensity is low or completely blocked by the GFC Wheel mask, the temperature of the detector is lowered by the two-stage thermo-electric cooler, increasing the detectors resistance and lowering the output voltage.

Synchronous Demodulator (Sync/Demod) Assembly

Overview

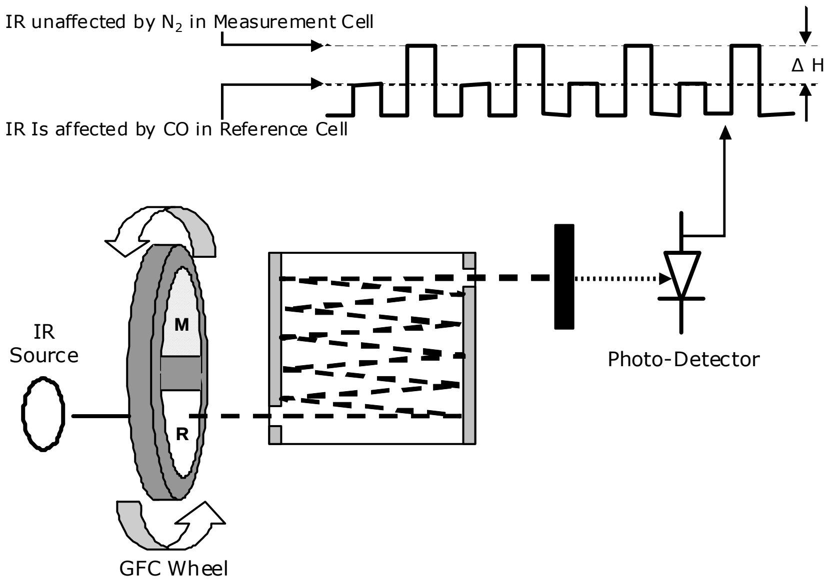
While the Photo-Detector converts fluctuations of the IR beam into electronic signals, the Sync / Demod Board amplifies these signals and converts them into usable information. Initially the output by the photo-detector is a complex and continuously changing waveform made up of Measure and Reference pulses. The Sync/Demod Board demodulates this waveform and outputs two analog DC voltage signals, corresponding to the peak values of these pulses. **CO MEAS** and **CO REF** are converted into digital signals by circuitry on the Motherboard then used by the CPU to calculate the CO concentration of the sample gas.

Additionally the Synch/Demod Board contains circuitry that controls the photo-detector's thermoelectric cooler as well as circuitry for performing certain diagnostic tests on the analyzer.



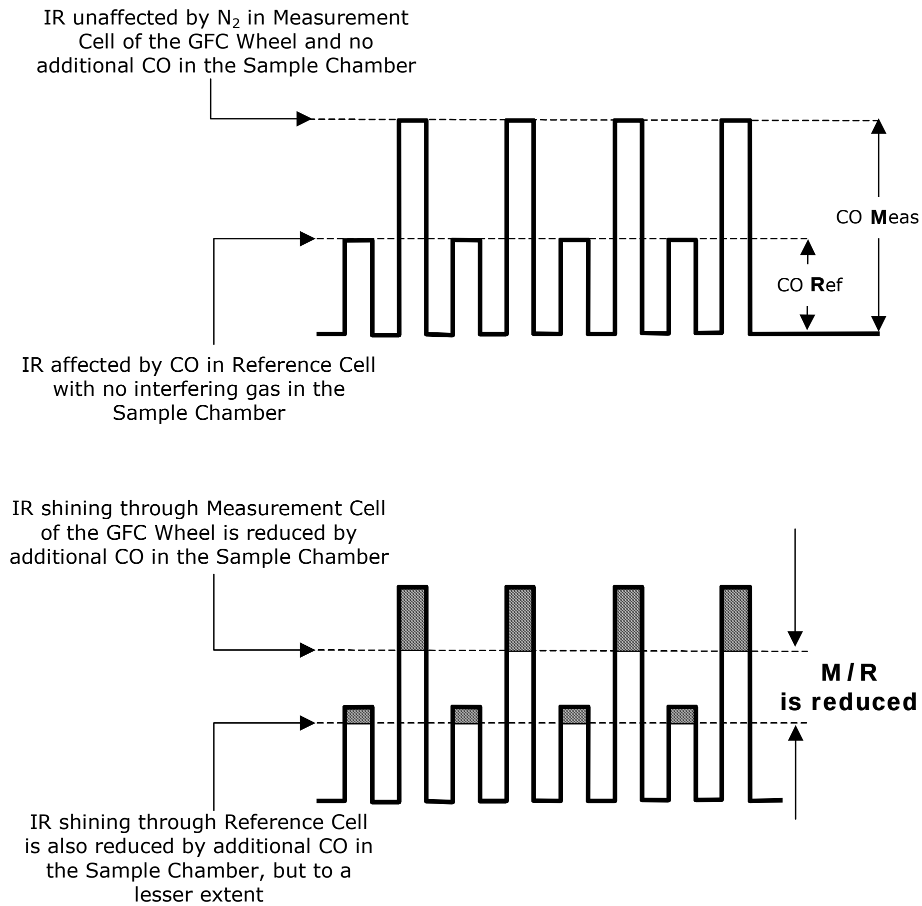
GFC Wheel

A GFC Wheel is a metallic wheel into which two chambers are carved. The chambers are sealed on both sides with material transparent to 4.7μm IR radiation creating two airtight cavities. Each cavity is filled with specially composed gases. One cell is filled with pure N_2 (the Measure Cell). The other is filled with a combination of N_2 and a high concentration of CO (the Reference Cell).



Measurement Fundamentals with GFC Wheel

As the GFC wheel spins, the IR light alternately passes through the two cavities. When the beam is exposed to the Reference Cell, the CO in the gas filter wheel strips the beam of most of the IR at 4.7µm. When the light beam is exposed to the Measurement Cell, the N_2 in the filter wheel does not absorb IR light. This results in a fluctuation in the intensity of the IR light striking the photo-detector. The output of the detector resembles a square wave. The Model 300E determines the amount of CO in the sample chamber by computing the ratio between the peak of the Measurement pulse (**CO MEAS**) and the peak of the Reference Pulse (**CO REF**).

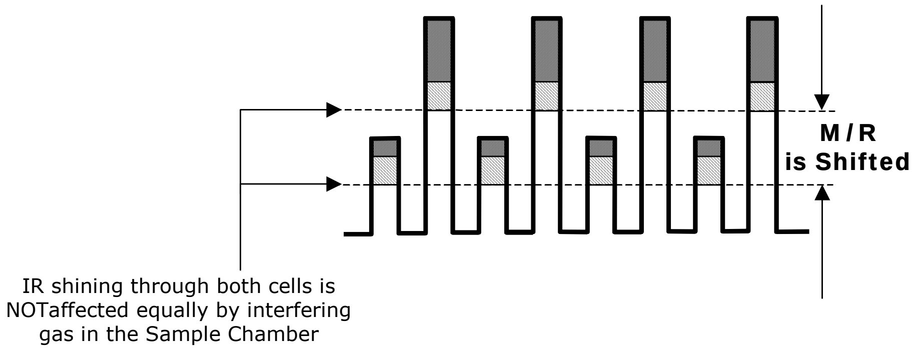


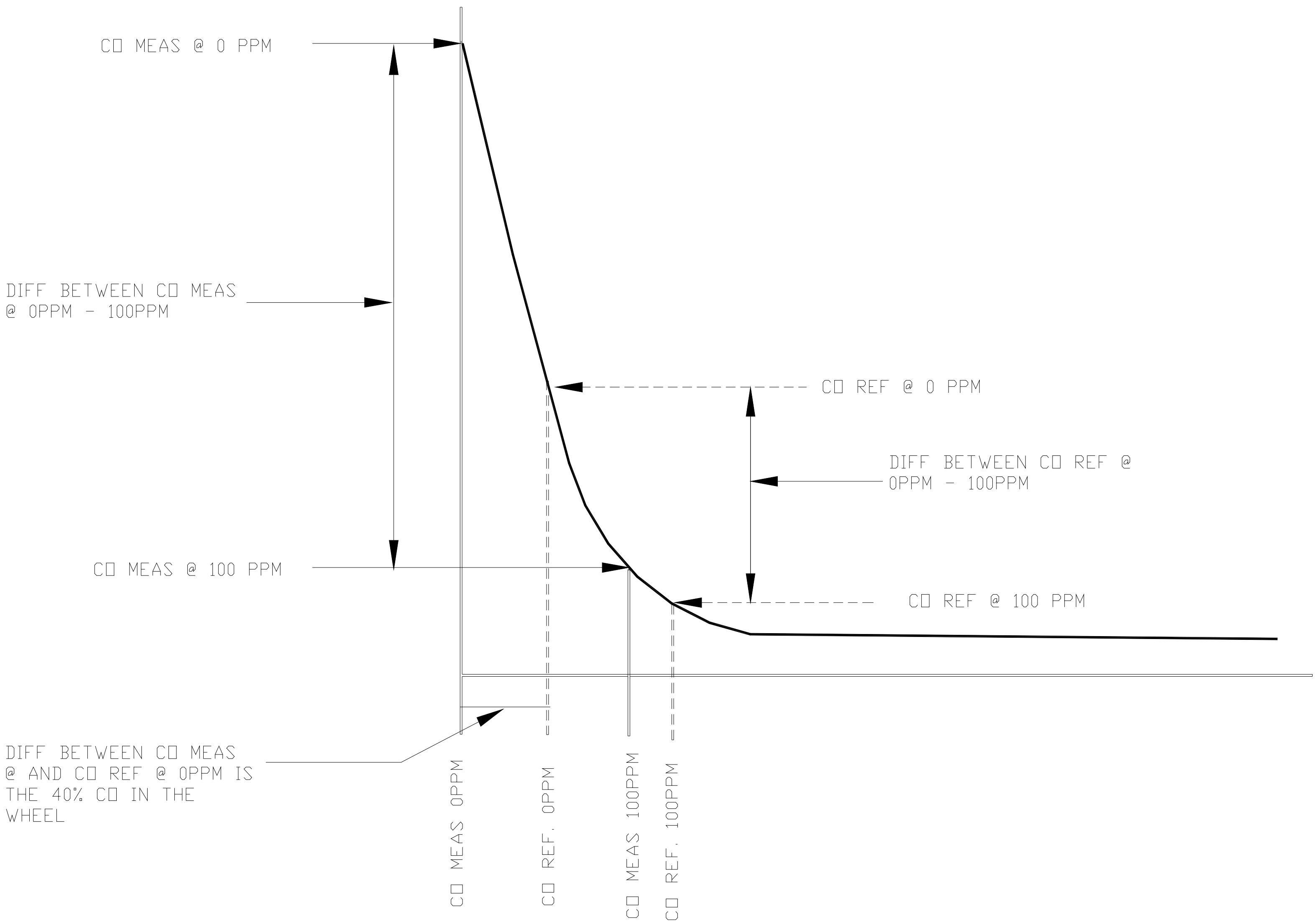
Effect of CO in the Sample on CO MEAS & CO REF

If no gases exist in the Sample chamber that absorb light at 4.7µm, the high concentration of CO in the gas mixture of the Reference Cell will attenuate the intensity of the IR Beam by 20% giving a M/R Ratio 0f 1.2:1.

Adding CO to the Sample Chamber causes the peaks corresponding to both cells to be attenuated by a further percentage. Since the intensity of the light passing through the Measurement Cell is greater, the effect of this additional attenuation is greater. This causes **CO MEAS** to be more sensitive to the presence of CO in the Sample Chamber than **CO REF** and the ratio between them (M/R) to move closer to 1:1 as the concentration of CO in the Sample Chamber increases.

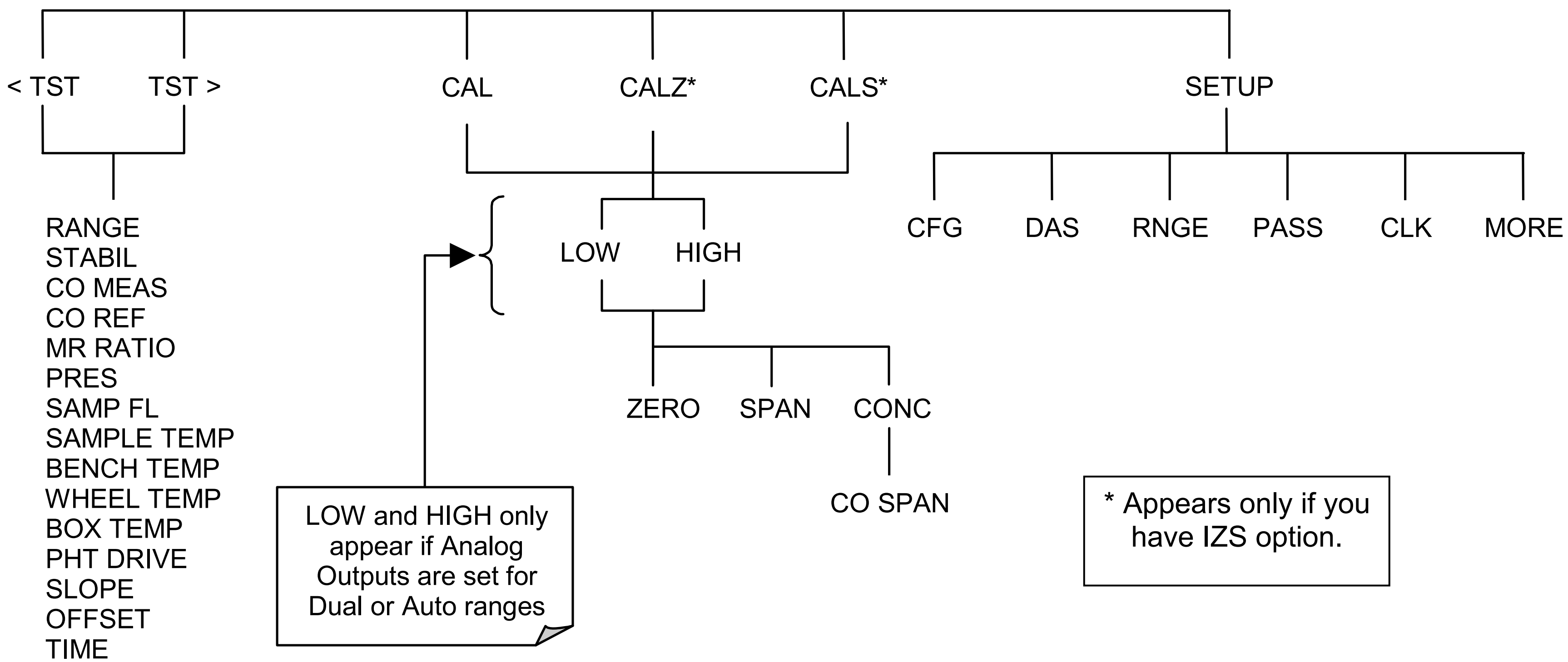
Once the Model 300E has computed this ratio, a look-up table is used, with interpolation, to linearize the response of the instrument. This linearized concentration value is combined with calibration **SLOPE** and **OFFSET** values to produce the CO concentration which is then normalized for changes in sample pressure.

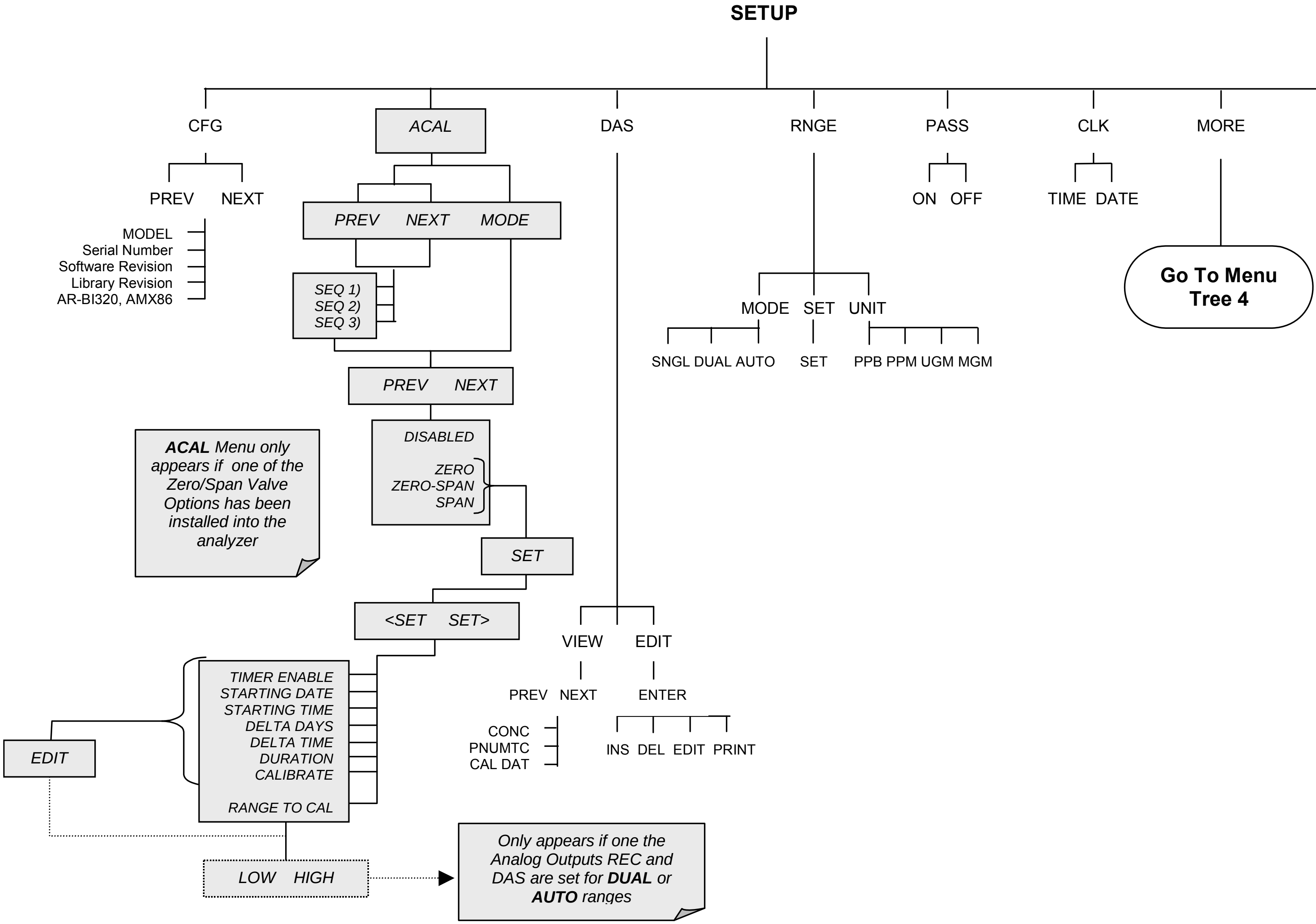

M / R
is Shifted
IR shining through both cells is
NOTaffected equally by interfering
gas in the Sample Chamber

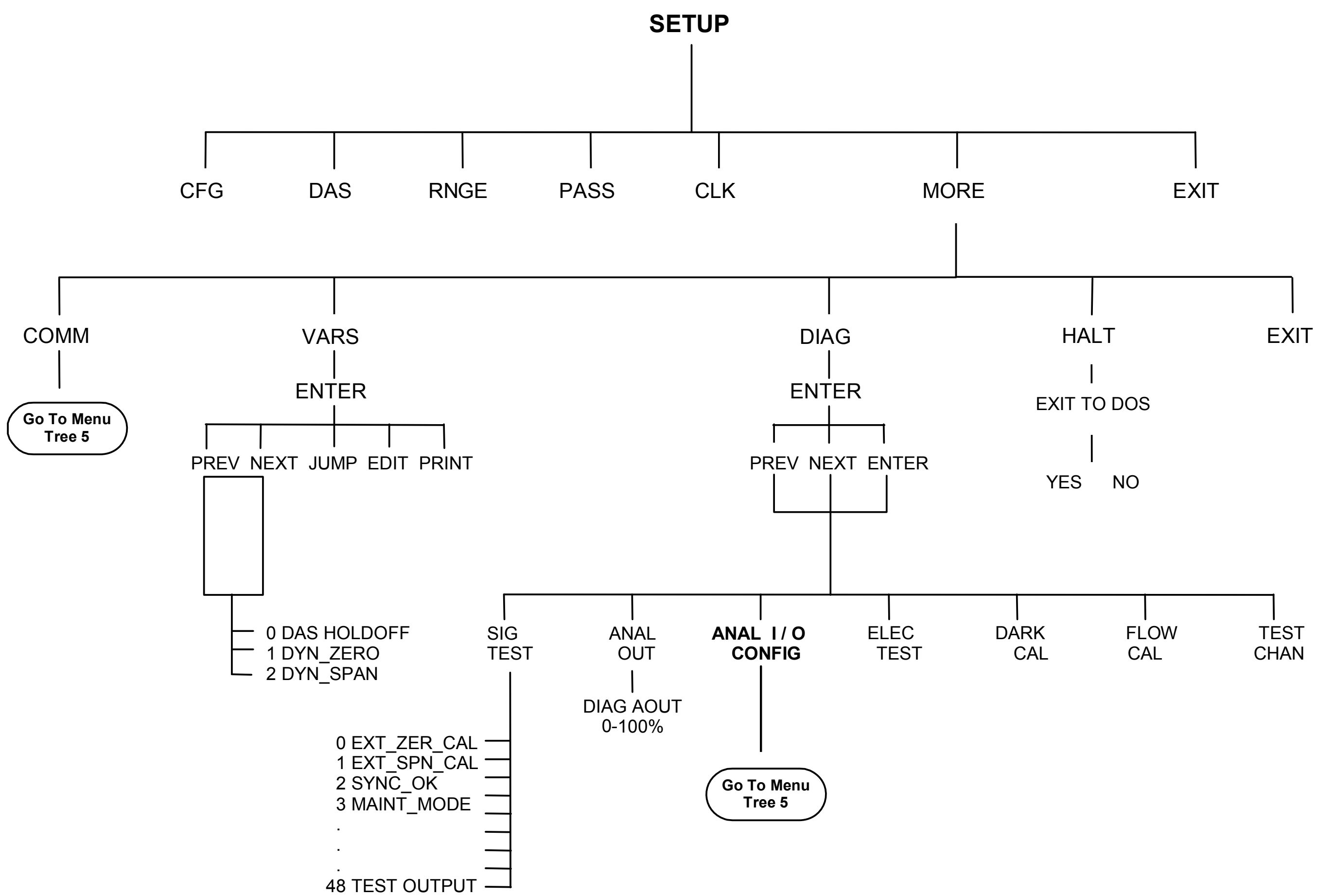

C□ MEAS @ 0 PPM
DIFF BETWEEN C□ MEAS @ 0PPM - 100PPM
C□ REF @ 0 PPM
DIFF BETWEEN C□ REF @ 0PPM - 100PPM
C□ MEAS @ 100 PPM
C□ REF @ 100 PPM
DIFF BETWEEN C□ MEAS @ AND C□ REF @ 0PPM IS THE 40% C□ IN THE WHEEL
C□ MEAS 0PPM
C□ REF. 0PPM
C□ MEAS 100PPM
C□ REF. 100PPM

3. MENU STRUCTURE

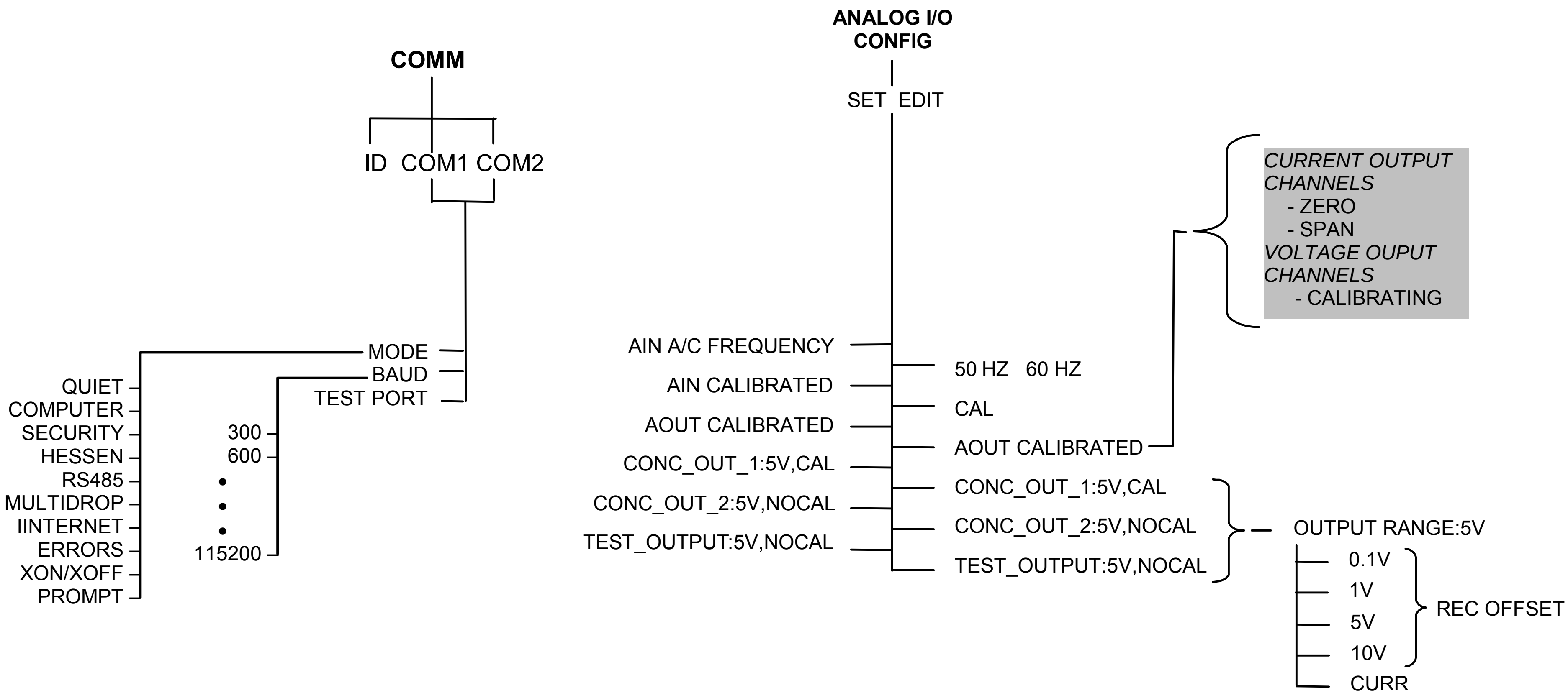
MENU TREE-: SAMPLE Mode Commands with Zero/Span Valve Options Installed




SETUP
CFG
ACAL
DAS
RNGE
PASS
CLK
MORE
EXIT
PREV NEXT
MODEL
Serial Number
Software Revision
Library Revision
AR-BI320, AMX86
PREV NEXT MODE
SEQ 1)
SEQ 2)
SEQ 3)
PREV NEXT
DISABLED
ZERO
ZERO-SPAN
SPAN
SET
<SET SET>
TIMER ENABLE
STARTING DATE
STARTING TIME
DELTA DAYS
DELTA TIME
DURATION
CALIBRATE
RANGE TO CAL
EDIT
LOW HIGH
ACAL Menu only appears if one of the Zero/Span Valve Options has been installed into the analyzer
Only appears if one the Analog Outputs REC and DAS are set for DUAL or AUTO ranges
VIEW EDIT
PREV NEXT
ENTER
CONC
PNUMTC
CAL DAT
INS DEL EDIT PRINT
MODE SET UNIT
SNGL DUAL AUTO
SET
PPB PPM UGM MGM
ON OFF
TIME DATE
Go To Menu Tree 4


SETUP
CFG
DAS
RNGE
PASS
CLK
MORE
EXIT
COMM
Go To Menu Tree 5
VARS
ENTER
PREV NEXT JUMP EDIT PRINT
0 DAS HOLDOFF
1 DYN_ZERO
2 DYN_SPAN
DIAG
ENTER
PREV NEXT ENTER
SIG TEST
0 EXT_ZER_CAL
1 EXT_SPN_CAL
2 SYNC_OK
3 MAINT_MODE
.
.
.
48 TEST OUTPUT
ANAL OUT
DIAG AOUT 0-100%
ANAL I / O CONFIG
Go To Menu Tree 5
ELEC TEST
DARK CAL
FLOW CAL
TEST CHAN
HALT
EXIT TO DOS
YES NO
EXIT

MENU TREE: SETUP Mode – MORE Menu Commands



MENU TREE: SETUP Mode – MORE, ANALOG I/O and COMM CONFIGURATION Menu Commands

User Notes:

4. CALIBRATION PROCEDURE

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Service Note

03-020B
2 MAY, 2007

HOW TO PERFORM A MANUAL DAC CALIBRATION ON "E" SERIES MACHINES

I. PURPOSE:
The purpose of this service note is to give instructions on how to perform a manual Digital to Analog Calibration (D/A Calibration) on "E" series analyzers.

II. TOOLS:
Digital Voltmeter

III. PARTS:
None

IV. PROCEDURE:

Please follow the appropriate procedure below for either VOLTAGE or CURRENT output.

VOLTAGE OUTPUT

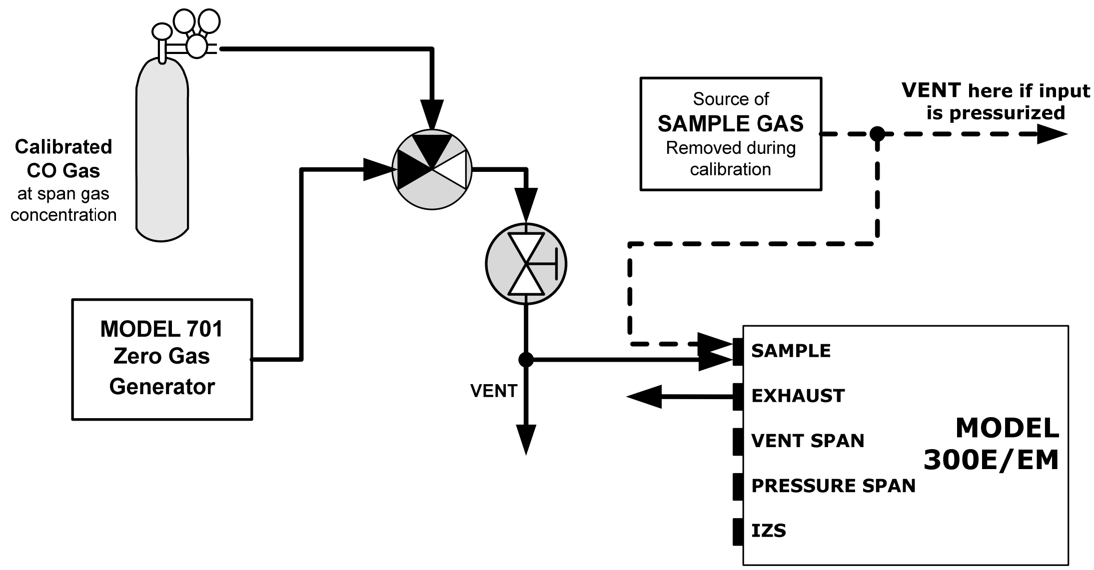
1. From the main menu press SETUP-MORE-DIAG-ENTR-NEXT until ANALOG I/O CONFIGURATION press ENTR.
2. Press SET> until it reads read A/IN CALIBRATED:
3. Press CAL to calibrate the analog inputs.
4. Press <SET until the top line reads CONC_OUT_1 and press EDIT
    a. If this is the output voltage you desire then go to step 7
    b. If this voltage is incorrect press EDIT and change to the output voltage desired, press ENTR and go to step 7.
5. Press EDIT, Press SET>. The top line should read CONC_OUT_1: REC OFFSET: 0mv
    a. If you don't want a recorder offset go to step 8.
    b. If you want a recorder offset press EDIT. Enter the OFFSET value and press ENTR. Go to step 8.
6. Press SET>. The top line should read CONC_OUT_1: AUTO CAL: ON
    a. If this says AUTO CAL ON press EDIT and turn it OFF.
    b. If this says AUTO CALL OFF go to step 9.
7. Press SET>. The top line should read CONC_OUT_1: CALIBRATED: YES
8. Now place your meter on pins 1 and 2 on the rear panel analog output connector and set your meter to read mvDC.
9. Press CAL on the front panel.

10. You should have some DN and UP buttons. And the top line should be say ZERO ADJUST or something similar.
11. The output on the meter should be as close as possible to 0mV ±0.3mV.
    a. If it is not then press DN or UP until the meter reads as close as possible to 0mv
    b. If it does go to step 14
12. Press ENTR.
13. The top line should now say GAIN ADJUST and you should have DN and UP buttons again. The meter should now read your full-scale voltage (i.e. 1V, 5V, 10V) you will have to change the range on the meter to read Volts instead of Mili-volts.
14. Press the DN and UP buttons until the output on the meter reads your full-scale voltage ±1mV.
15. Press ENTR
16. That channel is now calibrated.
17. Do this for all channels and ensure that you move the meter on the output connector to the proper pins.

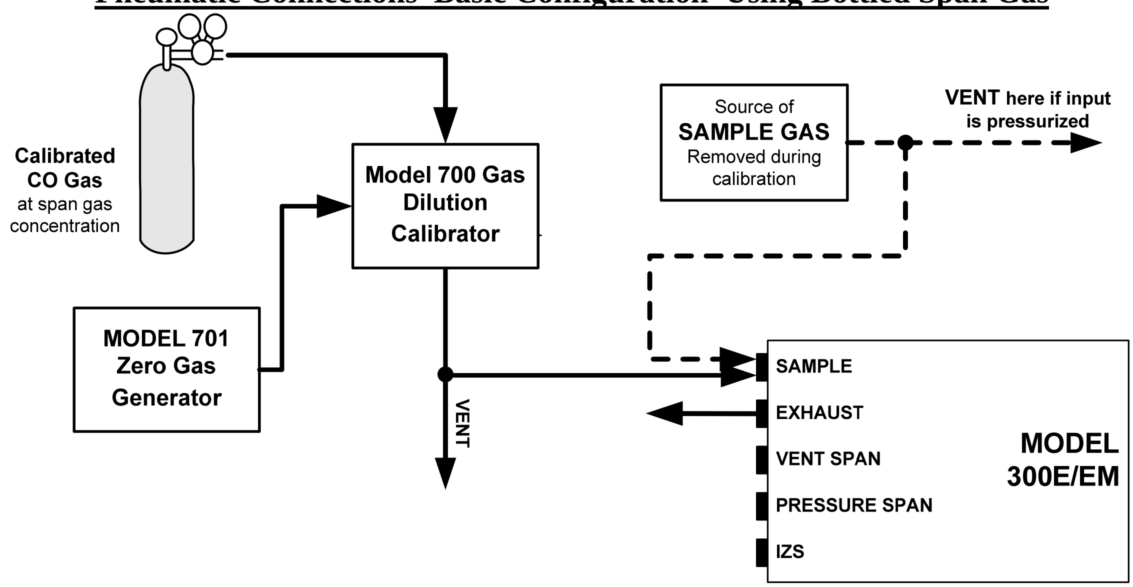
CURRENT OUTPUT

1. From the main menu press SETUP-MORE-DIAG-ENTR-NEXT until ANALOG I/O CONFIGURATION press ENTR.
2. Press SET> 5 times.
3. The top line should read A/IN CALIBRATED: YES
4. Press CAL to calibrate the analog inputs.
5. Press <SET 4 times.
6. The top line should read CONC_OUT_1: CURRENT
    a. If you desire Current output then go to step 7
    b. If you do not desire Current output press EDIT and change to the output voltage desired, press ENTR and follow the steps in the Voltage Output procedure.
7. Press EDIT, Press SET>. The top line should read CONC_OUT_1: AUTO CAL: ON
    a. If this says AUTO CAL ON press EDIT and turn it OFF.
    b. If this says AUTO CAL OFF go to step 8.
8. Press SET>. The top line should read CONC_OUT_1: CALIBRATED: YES
9. Now place your meter on pins 1 and 2 on the rear panel analog output connector and set your meter to read mA.
10. Press CAL on the front panel.
11. You should have some DN and UP buttons. And the top line should be say ZERO ADJUST or something similar.
12. The output on the meter should be as close as possible to 0ma ±0.01ma (if 0-20ma output), 4ma ±0.01ma (if 4-20ma output).
    a. If not then press DN or UP until the meter reads as close as possible to 0ma or 4ma.
    b. If it does go to step 13
13. Press ENTR.
14. The top line should now say GAIN ADJUST and you should have DN and UP buttons again. The meter should now read your full-scale current output 20ma.
15. If it doesn't press the DN and UP buttons until the output on the meter reads your full-scale current output of 20ma ±0.01ma.
16. Press ENTR
17. That channel is now calibrated.
18. Do this for all remaining channels that contain the Current option and ensure that you move the meter on the output connector to the proper pins for that channel.

Calibrating the M300E with Gas

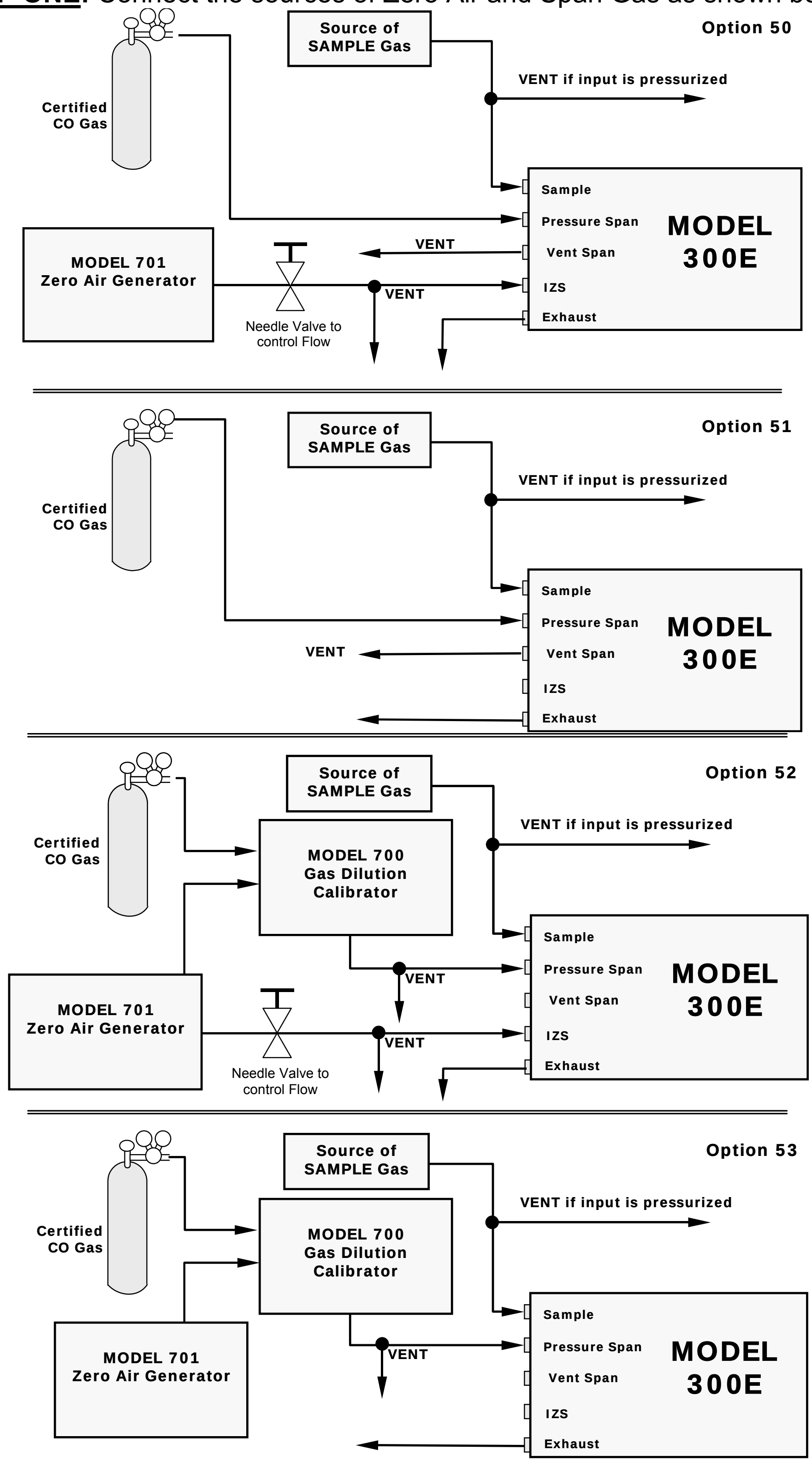


Pneumatic Connections–Basic Configuration–Using Bottled Span Gas



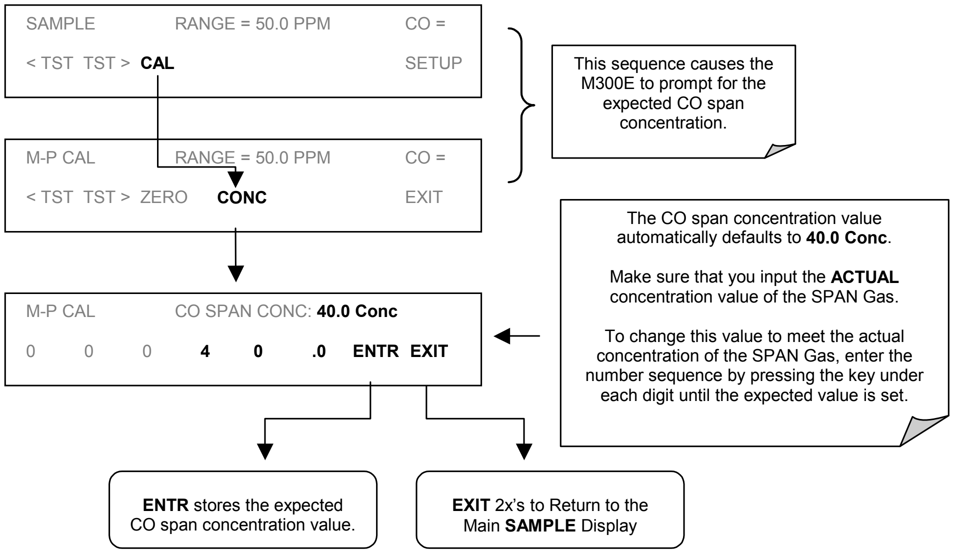
Pneumatic Connections–Basic Configuration–Using Gas Dilution Calibrator

STEP ONE: Connect the sources of Zero Air and Span Gas as shown below.



Pneumatic connections for Manual Calibration With Z/S Valves

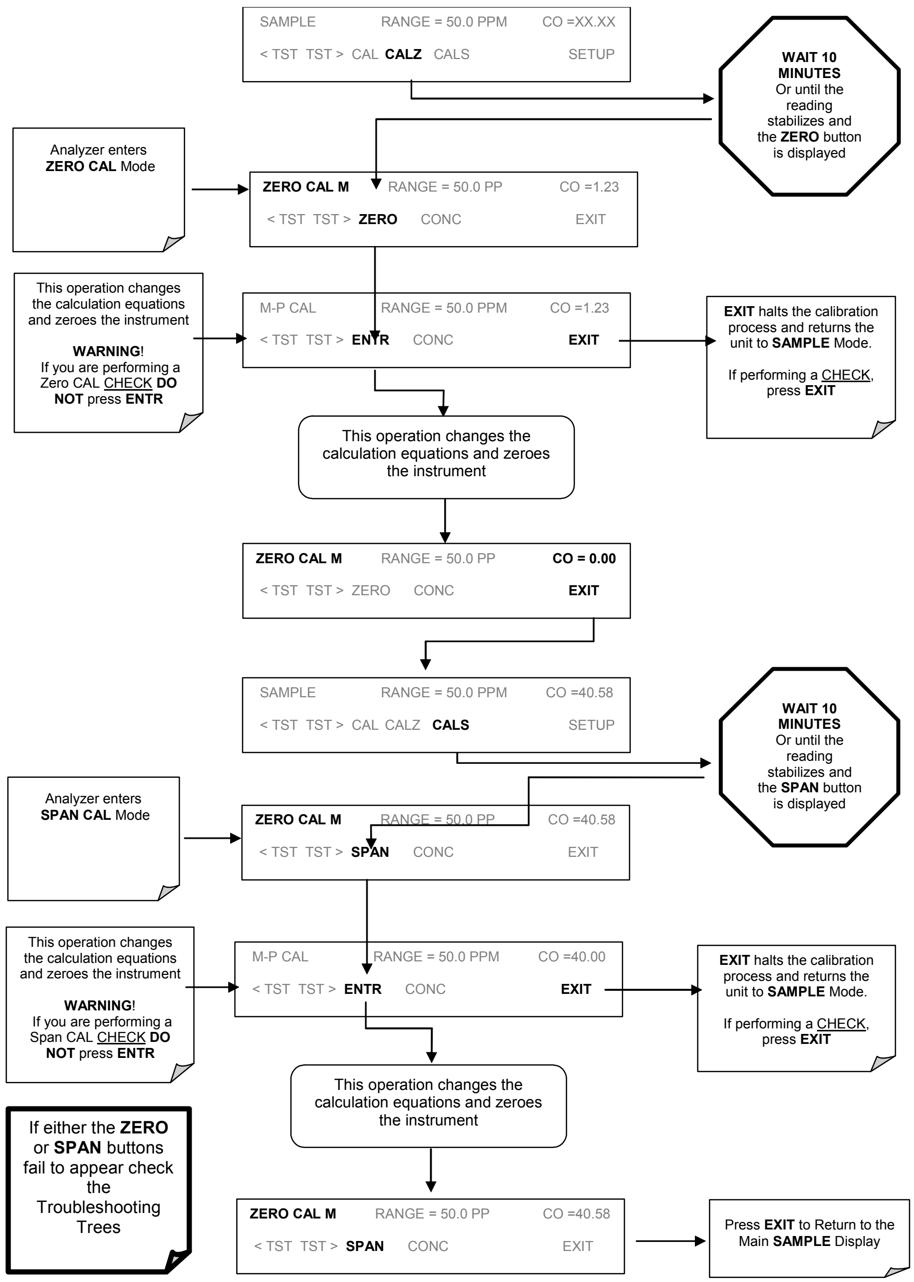
Set the expected CO Span Gas concentration:



NOTE

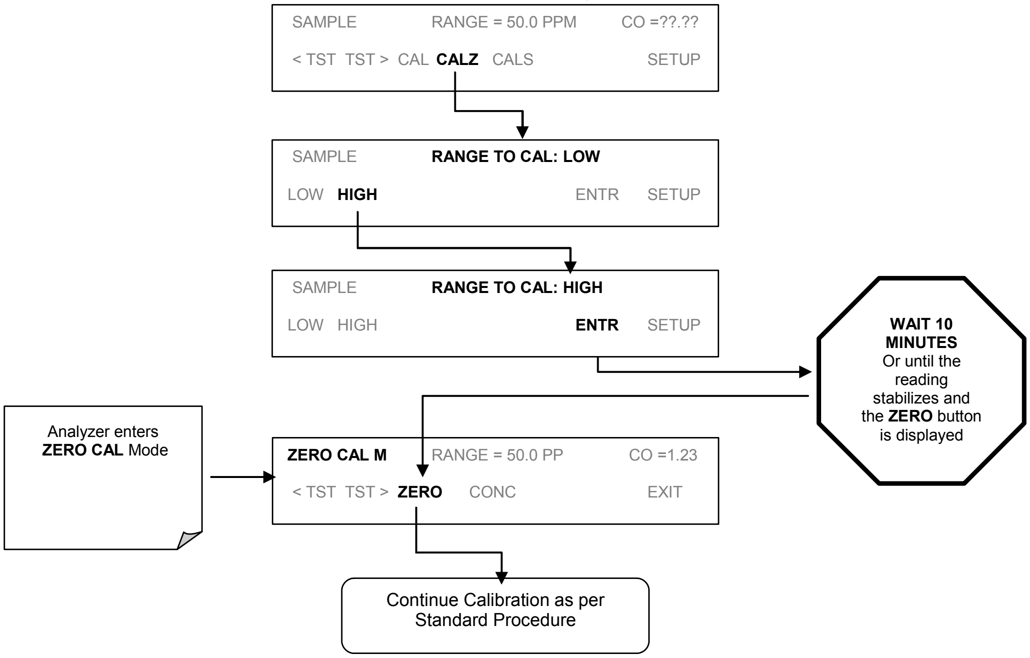
For this Initial Calibration it is important to independently verify the PRECISE CO Concentration Value of the SPAN gas.

If the source of the Span Gas is from a Calibrated Bottle, use the exact concentration value printed on the bottle.


SAMPLE RANGE = 50.0 PPM CO =XX.XX
< TST TST > CAL CALZ CALS SETUP
WAIT 10 MINUTES Or until the reading stabilizes and the ZERO button is displayed
Analyzer enters ZERO CAL Mode
ZERO CAL M RANGE = 50.0 PP CO =1.23
< TST TST > ZERO CONC EXIT
This operation changes the calculation equations and zeroes the instrument
WARNING! If you are performing a Zero CAL CHECK DO NOT press ENTR
M-P CAL RANGE = 50.0 PPM CO =1.23
< TST TST > ENTR CONC EXIT
EXIT halts the calibration process and returns the unit to SAMPLE Mode.
If performing a CHECK, press EXIT
This operation changes the calculation equations and zeroes the instrument
ZERO CAL M RANGE = 50.0 PP CO = 0.00
< TST TST > ZERO CONC EXIT
SAMPLE RANGE = 50.0 PPM CO =40.58
< TST TST > CAL CALZ CALS SETUP
WAIT 10 MINUTES Or until the reading stabilizes and the SPAN button is displayed
Analyzer enters SPAN CAL Mode
ZERO CAL M RANGE = 50.0 PP CO =40.58
< TST TST > SPAN CONC EXIT
This operation changes the calculation equations and zeroes the instrument
WARNING! If you are performing a Span CAL CHECK DO NOT press ENTR
M-P CAL RANGE = 50.0 PPM CO =40.00
< TST TST > ENTR CONC EXIT
EXIT halts the calibration process and returns the unit to SAMPLE Mode.
If performing a CHECK, press EXIT
This operation changes the calculation equations and zeroes the instrument
If either the ZERO or SPAN buttons fail to appear check the Troubleshooting Trees
ZERO CAL M RANGE = 50.0 PP CO =40.58
< TST TST > SPAN CONC EXIT
Press EXIT to Return to the Main SAMPLE Display

Zero/Span Calibration on Auto Range or Dual Ranges

If the analyzer is being operated in Dual Range mode or Auto Range mode, then the High and Low ranges must be independently calibrated. When the analyzer is in either Dual or Auto Range modes the user must run a separate calibration procedure for each range. After pressing the **CAL**, **CALZ** or **CALS** keys the user is prompted for the range that is to be calibrated as seen in the **CALZ** example below:

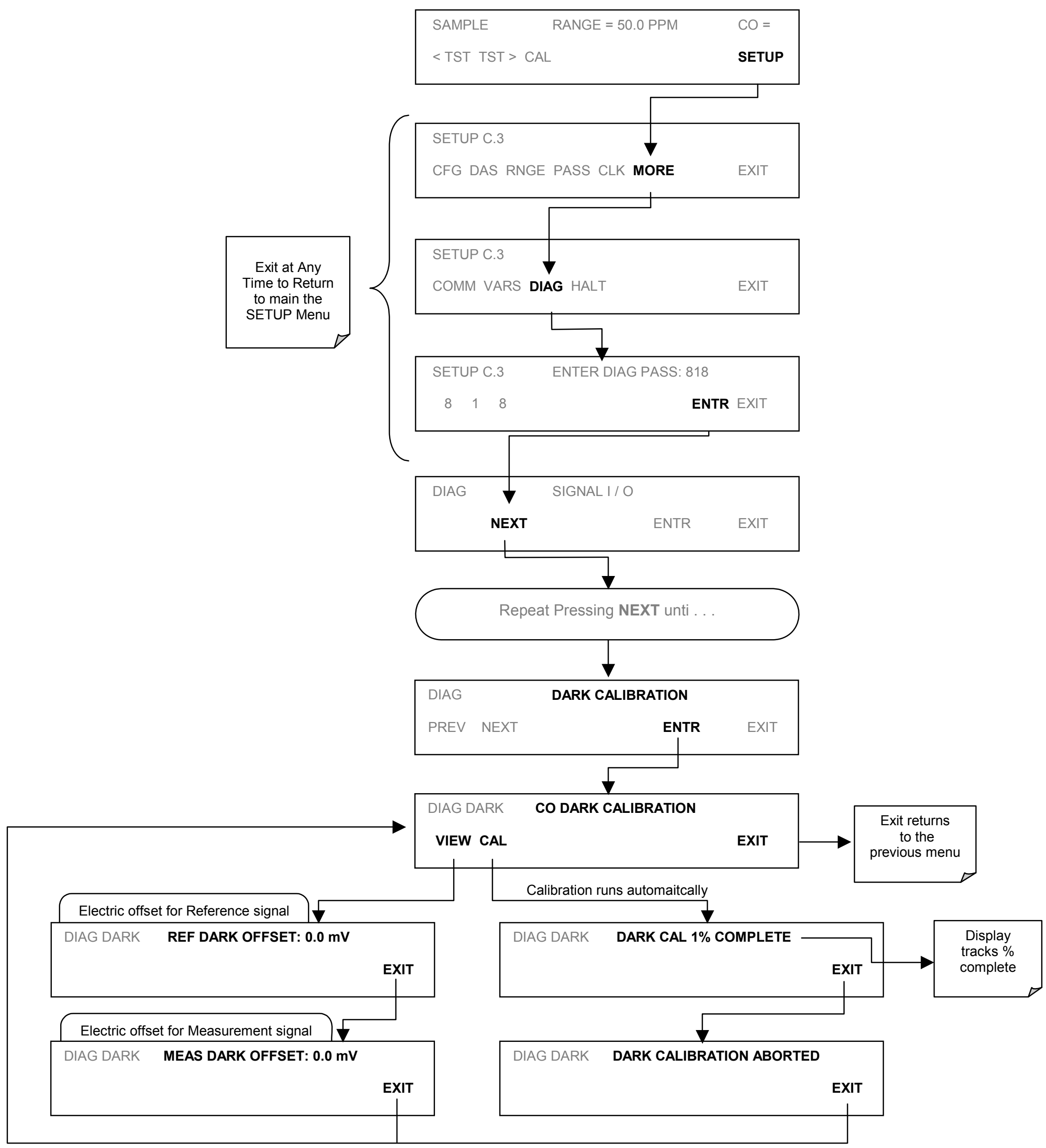


Repeat the sets to calibrate the Low Range as well. Both ranges must be calibrated.

Dark Calibration

The Dark Calibration Test interrupts the signal path between the IR Photo-Detector and the remainder of the Sync/Demod Board circuitry. This allows the instrument to compensate for any voltage levels inherent in the Sync/Demod circuitry that might effect the calculation of CO concentration. Performing this calibration returns two offset voltages, One for **CO MEAS** and on for **CO REF** that are automatically added to the CPU's calculation routine. The two offset voltages from the last calibration procedure may be reviewed by the user via the front panel display.

To activate the Dark Calibration procedure or review the results of a previous calibration, press:



Pressure Calibration

To calibrate the pressure in the analyzer the first thing you will want to do is disconnect the pump. You can either do this pneumatically or electrically. Also disconnect any tubing connected to the sample inlet or exhaust ports on the back of the analyzer. This will put the analyzer at atmospheric pressure.

Next, find out the current atmospheric pressure. This can be found from a barometer or contacting your local airport or weather station.

From the front panel of the analyzer press <SETUP><MORE><DIAG> and enter 929 for the password when ever it asks for it. Once in the DIAG menu scroll over until you get Pressure Calibration and hit ENTER. Now enter the current atmospheric pressure and press ENTER.

Exit back out to the main menu and scroll over to sample pressure. This should be equal to the atmospheric pressure now. Reconnect the pump and the pressure should drop a few inches. Reconnect the sample inlet and exhaust and the pressure should remain the same +- 0.2"Hg. If the pressure changes more then this when you reconnect the sample and exhaust lines you will have to troubleshoot the system as the analyzer is being pressurized or being put under a vacuum.

Flow Calibration

With the analyzer on and the pump connected, connect an external flow meter to the sample inlet port on the back of the analyzer. Record the flow rate. Then from the front panel hit <SETUP><MORE><DIAG> enter 929 for the password when it asks you for it.

Once in the DIAG menu scroll over until you get Flow Calibration and hit <ENTER><CAL>. Now enter the value you measured with the external flow meter and hit Enter. This will calibrate the flow meter in the analyzer. Exit back out to the main menu and scroll through the TST values till you get Flow. It will be readings close to the measured value.

Linearity Adjustment

On occasion the CO analyzer may need to be adjusted at a mid-point span, or a linearity adjustment. This procedure should only be performed if your mid-point/linearity point is out of spec.

The option for this must first be enabled in the analyzer. From the front panel press <SETUP><MORE><DIAG> enter 929 for the password when it asks you for it. Scroll over using the NEXT button until you get Factory Options. Hit ENTR, and scroll through this menu until you get LINEARITY ADJUST:OFF. Turn this ON and hit ENTR. Exit back to the main menu and power cycle the analyzer. When the analyzer powers back up, the option for the Lin Adjust has been enabled we can actually do the calibration.

First make sure to perform a Zero and Span calibration before performing the Lin Adjust, you will not be able to perform the Lin Adjust unless this has been done. To adjust the linearity point first press <SETUP><MORE><DIAG> enter 929 for the password when it asks you for it. Scroll over using the NEXT button until you get Linearity Adjustment and hit <ENTR> <CAL>.

Once in the Linearity Adjustment menu start flowing your mid point calibration gas. Next, press <CONC> Enter your mid point calibration gas value into this menu and hit <ENTR>. Wait at least 15 minutes or until the analyzer becomes stable. Press <SPAN><ENTR>. The concentration value should now match your mid point bottle of gas. Exit back to the main menu and return the analyzer to normal operation.

User Notes:

5. Maintenance

NOTE: The following table shows a typical maintenance schedule for the analyzer. Please note that in certain environments (i.e. dusty, very high ambient pollutant levels) some maintenance procedures may need to be performed more often than shown

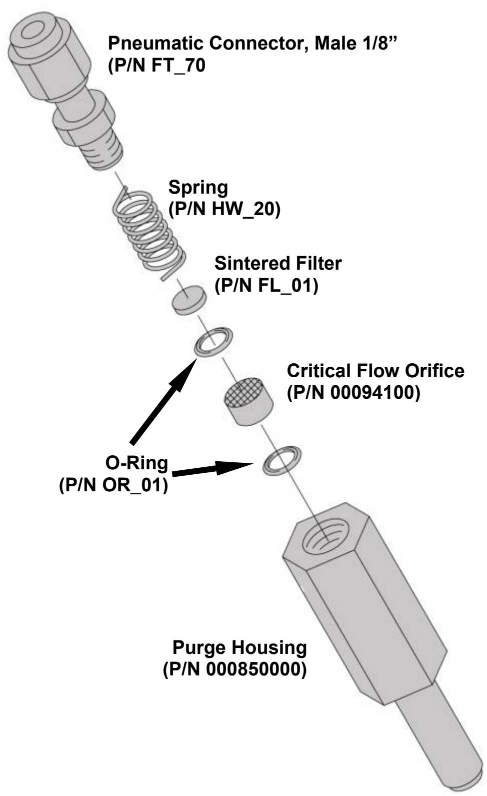
M300E Preventative Maintenance Schedule

Item	Action	Priority	Frequency	Cal Check	Date Performed								
Particulate Filter	Replace	Mandatory	Weekly or as needed	No									
Pump Diaphragm	Replace	Mandatory	Annually or as needed or repair	Yes									
Verify Test Functions	Record & analyze	Recommend	Weekly or after any maintenance	No									
Perform Flow Check	Check flow	Recommend	Annually or after any maintenance or repair	No									
Perform Leak Check	Verify leak tight	Recommend	Annually or after any maintenance or repair	Yes									
Pneumatic Lines	Examine and clean	As needed	As needed	Yes									
Cleaning	Clean	As needed	As needed	No									
Sintered Filter	Replace	As Needed	Annually	Yes									
Flow Control Orings	Replace	As Needed	Annually	Yes									
Orifice	Clean or replace	As Needed	Annually	Yes									

Repairing Sample Flow Control Assembly

The Critical Flow Orifice is housed in the Flow Control Assembly (T-API part number: 001760400) located on the inlet fitting of the pump. A sintered filter protects the jewel orifice so it is unusual for the orifice to need replacing, but if it does, or the filter needs replacement please use the following procedure:

1. Turn off Power to the analyzer.
2. Locate the assembly attached to the sample pump.
3. Disconnect the pneumatic connection from the flow assembly and the assembly from the pump.
4. Remove the fitting and the components as shown in the exploded view below.
5. Replace the o-rings (p/n:OR_01) and the sintered filter (p/n:FL_01).
6. If replacing the Critical Flow Orifice itself (p/n:000941000), make sure that the side with the colored window (usually Red) is facing upstream to the flow gas flow.
7. Re-assemble in reverse order.
8. After re-connecting the power and pneumatic lines, flow check the instrument.



Critical Flow Restrictor Assembly Disassembly

6. TROUBLESHOOTING & FAULTS

General Troubleshooting Hints

The analyzer has been designed so that problems can be rapidly detected, evaluated and repaired. 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.

A systematic approach to troubleshooting will generally consist of the following four steps:

1. Note any WARNING MESSAGES and take corrective action as required.
2. 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.
3. Use the Internal Electronic Status LED's to determine whether the CPU and I^2C buses are running, and if the Sync/Demodulator and Relay Board are operating properly. Verify that the DC power supplies are operating properly by checking the voltage test points on the Relay Board. Please note that the analyzer's DC power wiring is color-coded and these colors match the color of the corresponding test point on the relay board.
4. **SUSPECT A LEAK FIRST!** Data from T-API's Service Department indicates that 50% of ALL problems are eventually traced to leaks in the pneumatic connections and gas lines of the analyzer itself, the source of Zero Air or Span Gases or Sample Gas delivery system.

   Check for gas flow problems such as clogged or blocked internal/external gas lines, damaged seals, punctured gas lines, a damaged pump diaphragm, etc.

Customer Service Repair Questionnaire

CUSTOMER: ______________________________ PHONE: ______________________________

CONTACT NAME: ______________________________ FAX NO. ______________________________

SITE ADDRESS: ____

MODEL 300E SERIAL NO.: ________________ FIRMWARE REVISION:

____

1. ARE THERE ANY FAILURE MESSAGES? ____

____

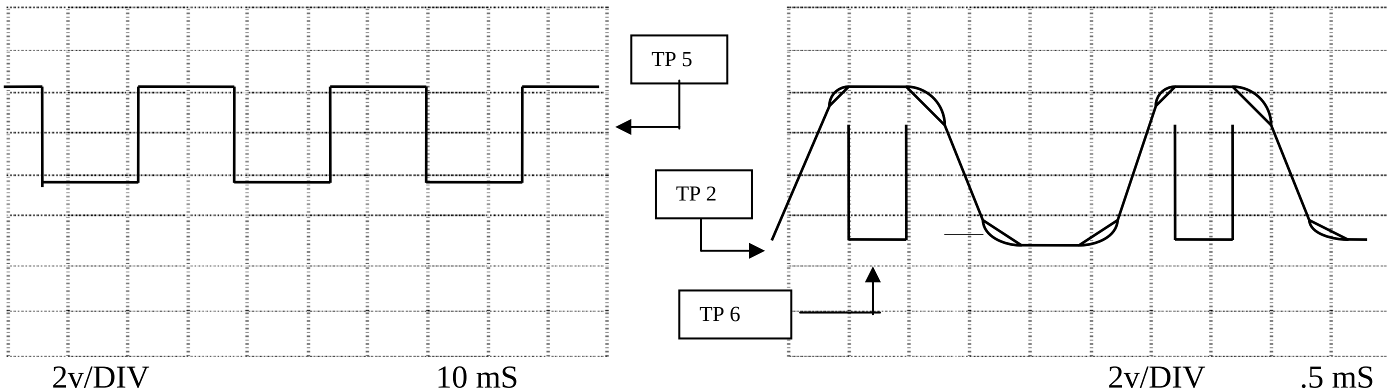
PLEASE COMPLETE THE FOLLOWING TABLE: ***(NOTE: DEPENDING ON OPTIONS INSTALLED, NOT ALL TEST PARAMETERS SHOWN BELOW WILL BE AVAILABLE IN YOUR INSTRUMENT)***

Parameter	Recorded Value	Acceptable Value
RANGE	PPM	1 – 1000 PPM
STABIL	PPM	≤ 0.05 PPM WITH ZERO AIR
CO MEASURE	mV	2500 – 4800 MV
CO REFERENCE	mV	2500 – 4800MV
MR RATIO		1.1 – 1.3 W/ ZERO AIR
PRESSURE	INHG	-2"AMBIENT ABSOLUTE
SAMPLE FLOW	CC	800 ± 10%
SAMPLE TEMP	ºC	48 ± 4
BENCH TEMP	ºC	48 ± 2
WHEEL TEMP	ºC	68 ± 2
BOX TEMP	ºC	AMBIENT + 7 ± 10
PHOTO DRIVE	mV	250mV TO 4750mV
SLOPE	.	1.0 ± .3
OFFSET		0 ± 0.3
DARK REF	mV	125 ± 50 mV.
DARK MEAS	mV	125 ± 50 mV
ETEST	PPM	40 ± 2 PPM
Values are in the Signal I/O		
REF_4096_MV		4096mv±2mv and Must be Stable
REF_GND		0± 0.5 and Must be Stable

2. WHAT IS THE SAMPLE FLOW & SAMPLE PRESSURE WITH THE SAMPLE IN-LET ON REAR OF MACHINE CAPPED?

   SAMPLE FLOW- __________CC **SAMPLE PRESSURE -** __________ IN-HG-A

3. PLEASE CHECK THESE SIGNALS AND VERIFY THE CORRECTNESS. LOOK FOR THE SIGNALS ANNOTATED ON THE DIAGRAM. WHAT ARE THE PEAK-TO-PEAK VOLTAGES?



4. IF POSSIBLE, PLEASE INCLUDE A PORTION OF A STRIP CHART PERTAINING TO THE PROBLEM. CIRCLE PERTINENT DATA. THANK YOU FOR PROVIDING THIS INFORMATION. YOUR ASSISTANCE ENABLE TELEDYNE API TO RESPOND FASTER TO THE PROBLEM THAT YOU ARE ENCOUNTERING.

Fault Diagnosis with TEST Functions

Besides being useful as predictive diagnostic tools, the Test Functions viewable from the Front Panel can be used to isolate and identify many operational problems when combined with a thorough understanding of the analyzers Principle of Operation.

The acceptable ranges for these Test Functions are listed in the “Nominal Range” column of the analyzer Final Test and Validation Data Sheet (p/n 04307) shipped with the instrument. Values outside these acceptable ranges indicate a failure of one or more of the analyzers subsystems. Functions whose values are still within the acceptable range but have significantly changed from the measurement recorded on the factory data sheet may also indicate a failure.

The following table contains some of the more common causes for these values to be out of range.

Test Functions - Indicated Failures

Test Functions (As Displayed)	**Indicated Failure(s)**
TIME	Time of Day clock is too fast or slow ▪ To adjust change the Clock_ADJ in the VARS menu. ▪ Battery in clock chip on CPU board may be dead.
RANGE	Incorrectly configured Measurement Range(s) could cause response problems with a Datalogger or Chart Recorder attached to one of the Analog Output. If the Range selected is too small, the recording device will over range. If the Range is too big, the device will show minimal or no apparent change in readings.
STABIL	Indicates noise level of instrument or CO concentration of Sample Gas
CO MEAS & CO REF	If the value displayed is too high the IR Source has become brighter. Adjust the variable gain potentiometer on the Sync/Demod Board If the value displayed is too low or constantly changing AND: The **CO REF** is OK: ▪ Failed Multiplexor on the Mother Board ▪ Failed Sync/Demod Board ▪ Loose Connector or wiring on Sync/Demod Board The **CO REF** is also BAD: ▪ GFC Wheel stopped or rotation is too slow ▪ Failed Sync/Demod Board IR Source ▪ Failed IR Source ▪ Failed Relay Board ▪ Failed I^2C Bus ▪ Failed IR Photo-Detector
MR Ratio	When the analyzer is sampling Zero Air and the ratio is too low: ▪ The Reference Cell of the GFC Wheel is contaminated or leaking. ▪ The alignment between the GFC Wheel and the Segment Sensor, the M/R Sensor or both is incorrect. ▪ Failed Sync/Demod Board When the analyzer is sampling Zero Air and the ratio is too high: ▪ Zero Air is contaminated ▪ The alignment between the GFC Wheel and the Segment Sensor, the M/R Sensor or both is incorrect. ▪ Failed Sync/Demod Board ▪ Failed IR Photo-Detector
SAMPLE FL	Check for Gas Flow problems.
SAMPLE TEMP	Sample temp should be close to **BENCH TEMP**. Temperatures outside of the specified range or oscillating temperatures are cause for concern
BENCH TEMP	Bench temp control improves instrument noise, stability and drift. Temperatures outside of the specified range or oscillating temperatures are cause for concern.
WHEEL TEMP	Wheel temp control improves instrument noise, stability and drift. Outside of set point or oscillating temperatures are cause for concern.
BOX TEMP	If the Box Temperature is out of range, check fan in the Power Supply Module. Areas to the side and rear of instrument should allow adequate ventilation.
PHT DRIVE	If this drive voltage is out of range it may indicate one of several problems: - A poor mechanical connection between the various components in inside the

Test Functions (As Displayed)	**Indicated Failure(s)**
	detector housing - An electronic failure of the IR Photo-Detector's built-in cooling circuitry, or; - A temperature problem inside the analyzer chassis. In this case other temperature warnings would also be active such as **BENCH TEMP WARNING** or **BOX TEMP WARNING**.
SLOPE	Values outside range indicate ▪ Contamination of the Zero Air or Span Gas supply ▪ Instrument is miss-calibrated ▪ Blocked Gas Flow ▪ Contaminated or leaking GFC Wheel (either chamber) ▪ Faulty IR Photo-Detector ▪ Faulty Sample Pressure Sensor (P1) or circuitry ▪ Invalid M/R ratio (see above) ▪ Bad/incorrect Span Gas concentration due.
OFFSET	Values outside range indicate ▪ Contamination of the Zero Air supply ▪ Contaminated or leaking GFC Wheel (either chamber) ▪ Faulty IR Photo-Detector

Internal Electronic Status LED's

Several LED's are located inside the instrument to assist in determining if the analyzers CPU, I^2C bus and Relay Board, GFC wheel and the Sync/Demodulator Board are functioning properly.

Temperature

There are three possible failures that could cause the Bench temperature to be incorrect.

1. The heater mounted to the bottom of the Absorption bench is electrically shorted or open. Check the resistance of the two heater elements by measuring between pin 2 and 4 (~76 Ohms), and pin 3 and 4 (~330 Ohms), of the white five-pin connector just below the sample temperature sensor on the Bench (pin 1 is the pointed end).
2. Assuming that the I^2C bus is working and that there is no other failure with the Relay board, the solid-state relay (K2) on the Relay Board may have failed. Using the BENCH_HEATER parameter under the Signal I/O function, turn on and off K2 (D3 on the relay board should illuminate as the heater is turned on). Check the AC voltage present between pin 2 and 4, for a 100 or 115 VAC model, and pins 3 and 4, for a 220-240 VAC model.

   WARNING: HAZARDOUS VOLTAGES ARE PRESENT DURING THIS TEST

   If the relay has failed there should be no change in the voltage across pins 2 and 4 or 3 and 4. Note, K2 is in a socket for easy replacement.
3. If K2 checks out OK, the thermistor temperature sensor located on the optical bench near the front of the instrument could be at fault. Unplug the connector labeled "Bench", and measure the resistance of the thermistor. At room temperature it should have approximately 30K Ohms resistance, near the 48^{o}C setpoint it should have ~11K Ohms.

GFC Wheel Temperature

Like the Bench Heater above there are three possible causes for the GFC wheel temperature to have failed.

1. The Wheel heater has failed. Check the resistance between pins 1 and 4 on the white five-pin connector just below the sample temperature sensor on the Bench (pin 1 is the pointed end). It should be approximately 275 Ohms.
2. Assuming that the I^2C bus is working and that there is no other failure with the Relay board, the solid-state relay (K1) on the Relay Board may have failed. Using the WHEEL_HEATER parameter under the Signal I/O function, turn on and off K1 (D2 on the relay board should illuminate as the heater is turned on). Check the AC voltage present between pin 1 and 4.

   WARNING: Hazardous Voltages are present during this test

   If the relay has failed there should be no change in the voltage across pins 1 and 4. Note, K1 is socketed for easy replacement.
3. If K1 checks out OK, the thermistor temperature sensor located at the front of the filter wheel assembly may have failed. Unplug the connector labeled "Wheel", and measure the resistance of the thermistor. The resistance near the 68^{o}C setpoint is ~5.7k ohms.

Excessive Noise

Noise is continuously monitored in the TEST functions as the **STABIL** reading and only becomes meaningful after sampling a constant gas concentration for at least 10 minutes. Compare the current **STABIL** reading with that recorded at the time of manufacture (included in the M300E Final Test and Validation Data sheet-p/n 04271 shipped with the unit from T-API).

1. The most common cause of excessive noise is leaks. Leak check and flow check the instrument.
2. Detector failure – caused by failure of the hermetic seal or over-temperature due to poor heat sinking of the detector can to the optical bench. In addition to increased noise due to poor signal-to-noise ratio, another indicator of detector failure is a drop in the signal levels of the CO Measure signal and CO Reference signal.
3. Sync/Demod Board failure. There are many delicate, high impedance parts on this board. Check the **CO MEAS** and **CO REF** Test Functions via the Front Panel Display.
4. The detector cooler control circuit can fail for reasons similar to the detector itself failing. Symptoms would be a change in **MR RATIO** Test Function when zero air is being sampled.

The +5 and ±15 VDC voltages in the M300E are provided by switching power supplies. Switch mode supplies create DC outputs by switching the input AC waveform at high frequencies. As the components in the switcher age and degrade, the main problem observed is increased noise on the DC outputs. If a noisy switcher power supply is suspected, attach an oscilloscope to the DC output test points located on the top right hand edge of the Relay board. Look for short period spikes > 100 mV p-p on the DC output.

GFC Wheel Drive

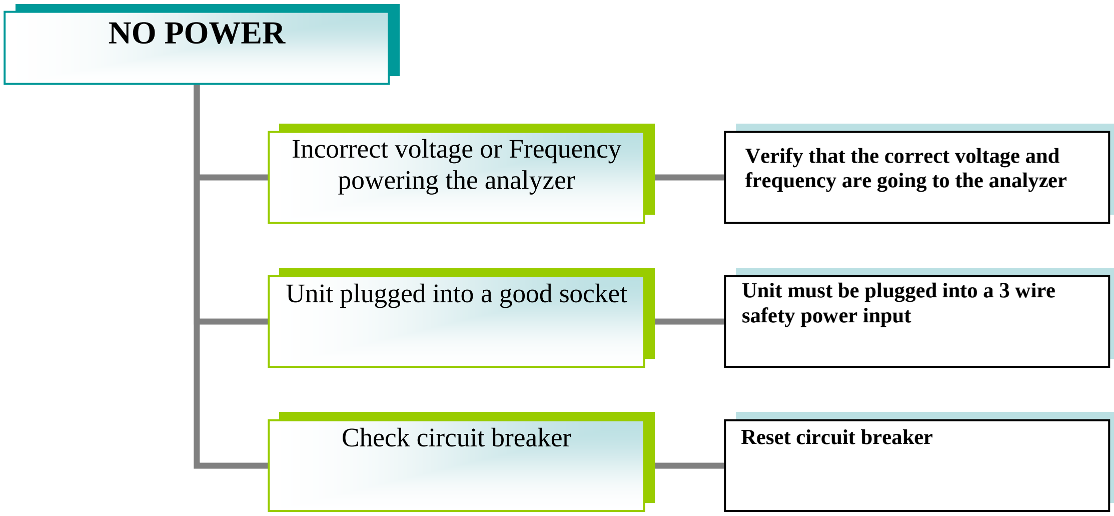
If the D1 and D2 on the Sync Demodulator board are not flashing then:

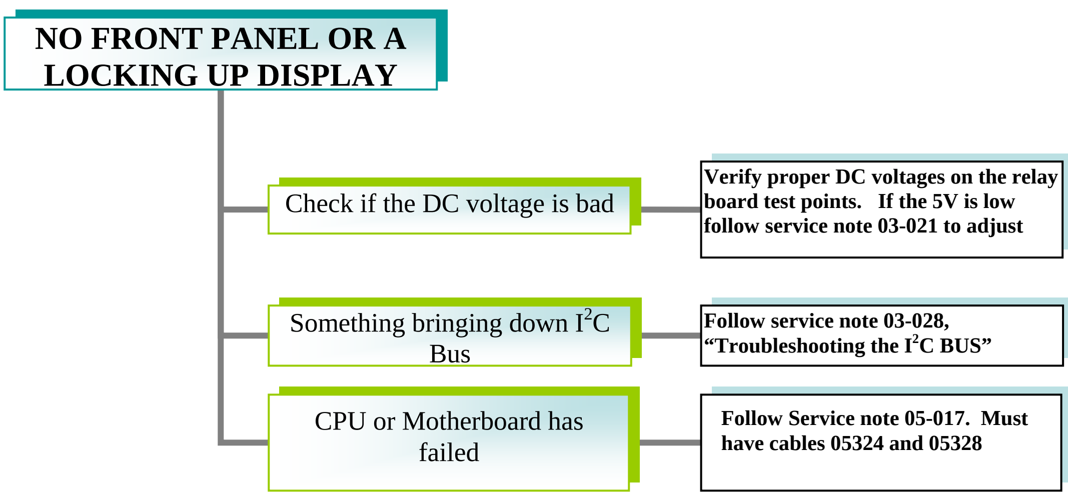
1. Check for power to the motor by measuring between pins 1 and 3 on the connector feeding the motor. For instruments configured for 120 or 220-240VAC there should be approximately 88 VAC for instruments configured for 100VAC, it should be the voltage of the AC mains, approximately 100VAC.
2. Verify that the frequency select jumper, JP4, is properly set on the Relay Board. For 50 Hz operation it should be installed. For 60 Hz operation may either be missing or installed in a vertical orientation.
3. If there is power to the motor and the frequency select jumper is properly set then the motor is likely bad.

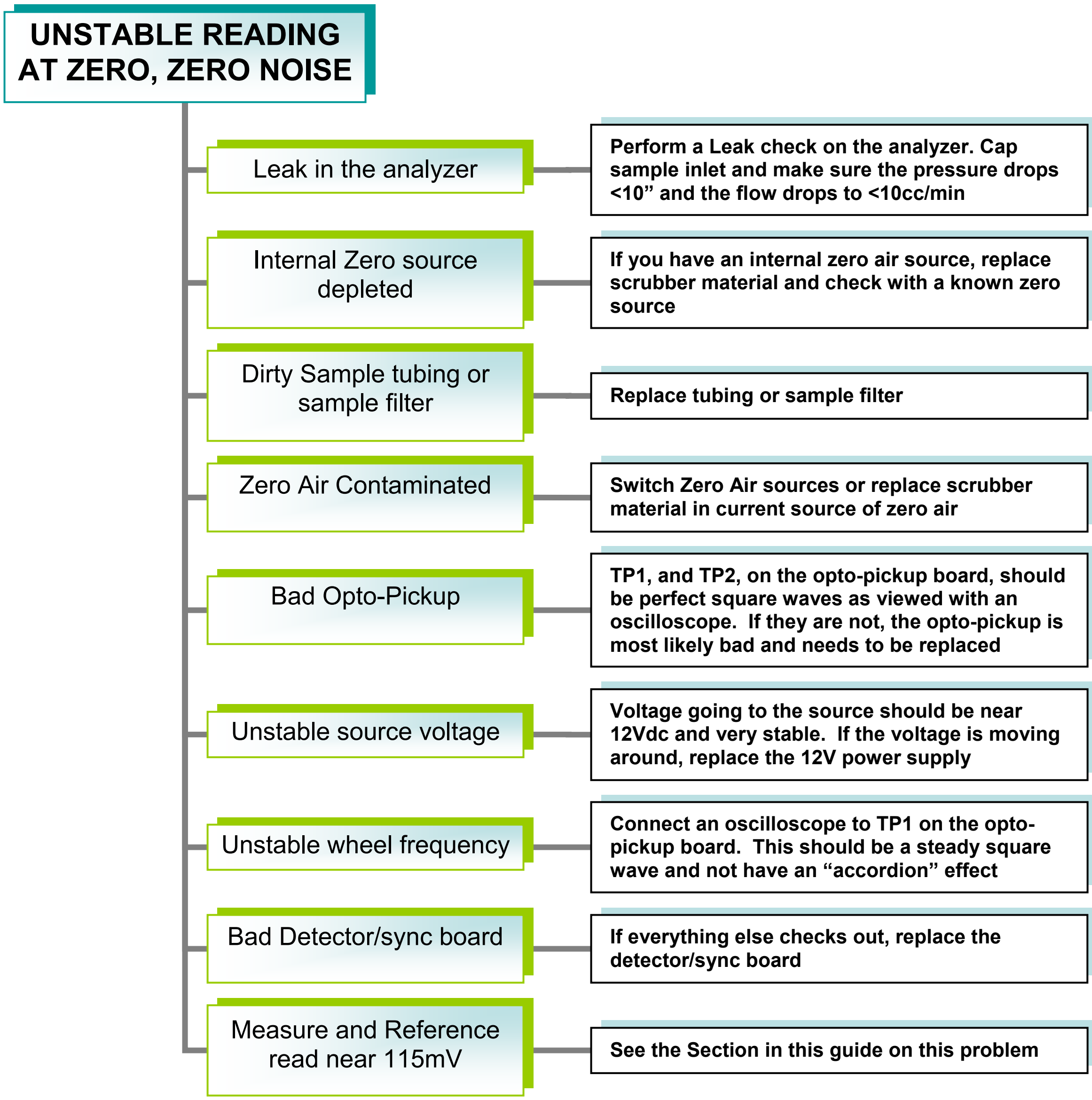
M300E Troubleshooting Tree

Troubleshooting Trees

No Power
No front panel or locking up Display
Unstable Reading at Zero, Zero noise
Unstable Reading at Span, Span noise
Unable to Zero (No Zero Button)
Unable to Span (No Span button or no response to Span gas)
Non-Linear Response
Slow Response to Zero or Span
No Flow
No analog or incorrect analog output
Measure and Reference both Around 115mV, Sync Warning, or Source Warning
Any Temperature Warning


NO POWER
Incorrect voltage or Frequency powering the analyzer
Verify that the correct voltage and frequency are going to the analyzer
Unit plugged into a good socket
Unit must be plugged into a 3 wire safety power input
Check circuit breaker
Reset circuit breaker


NO FRONT PANEL OR A LOCKING UP DISPLAY
Check if the DC voltage is bad
Verify proper DC voltages on the relay board test points. If the 5V is low follow service note 03-021 to adjust
Something bringing down I^2C Bus
Follow service note 03-028, "Troubleshooting the I^2C BUS"
CPU or Motherboard has failed
Follow Service note 05-017. Must have cables 05324 and 05328


UNSTABLE READING AT ZERO, ZERO NOISE
Leak in the analyzer
Perform a Leak check on the analyzer. Cap sample inlet and make sure the pressure drops <10” and the flow drops to <10cc/min
Internal Zero source depleted
If you have an internal zero air source, replace scrubber material and check with a known zero source
Dirty Sample tubing or sample filter
Replace tubing or sample filter
Zero Air Contaminated
Switch Zero Air sources or replace scrubber material in current source of zero air
Bad Opto-Pickup
TP1, and TP2, on the opto-pickup board, should be perfect square waves as viewed with an oscilloscope. If they are not, the opto-pickup is most likely bad and needs to be replaced
Unstable source voltage
Voltage going to the source should be near 12Vdc and very stable. If the voltage is moving around, replace the 12V power supply
Unstable wheel frequency
Connect an oscilloscope to TP1 on the opto-pickup board. This should be a steady square wave and not have an “accordion” effect
Bad Detector/sync board
If everything else checks out, replace the detector/sync board
Measure and Reference read near 115mV
See the Section in this guide on this problem

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UNSTABLE READING AT SPAN, SPAN NOISE

Possible Cause	Action
Leak in the analyzer	**Perform a Leak check on the analyzer. Cap sample inlet and make sure the pressure drops <10” and the flow drops to <10cc/min**
Dirty Sample tubing or sample filter	**Replace tubing or sample filter**
Bad Opto-Pickup	**TP1, and TP2, on the opto-pickup board, should be perfect square waves as viewed with an oscilloscope. If they are not, the opto-pickup is most likely bad and needs to be replaced**
Unstable source voltage	**Voltage going to the source should be near 12Vdc and very stable. If the voltage is moving around replace the 12V power supply**
Unstable wheel frequency	**Connect an oscilloscope to TP1 on the opto-pickup board. This should be a steady square wave and not have an “accordion” effect**
Bad Detector/sync board	**If everything else checks out, replace the detector/sync board**
Measure and Reference read near 115mV	**See the Section in this guide on this problem**
Input gas not at ambient pressure	**Make sure the gas going to the analyzer is at ambient pressure, if not vent it properly**

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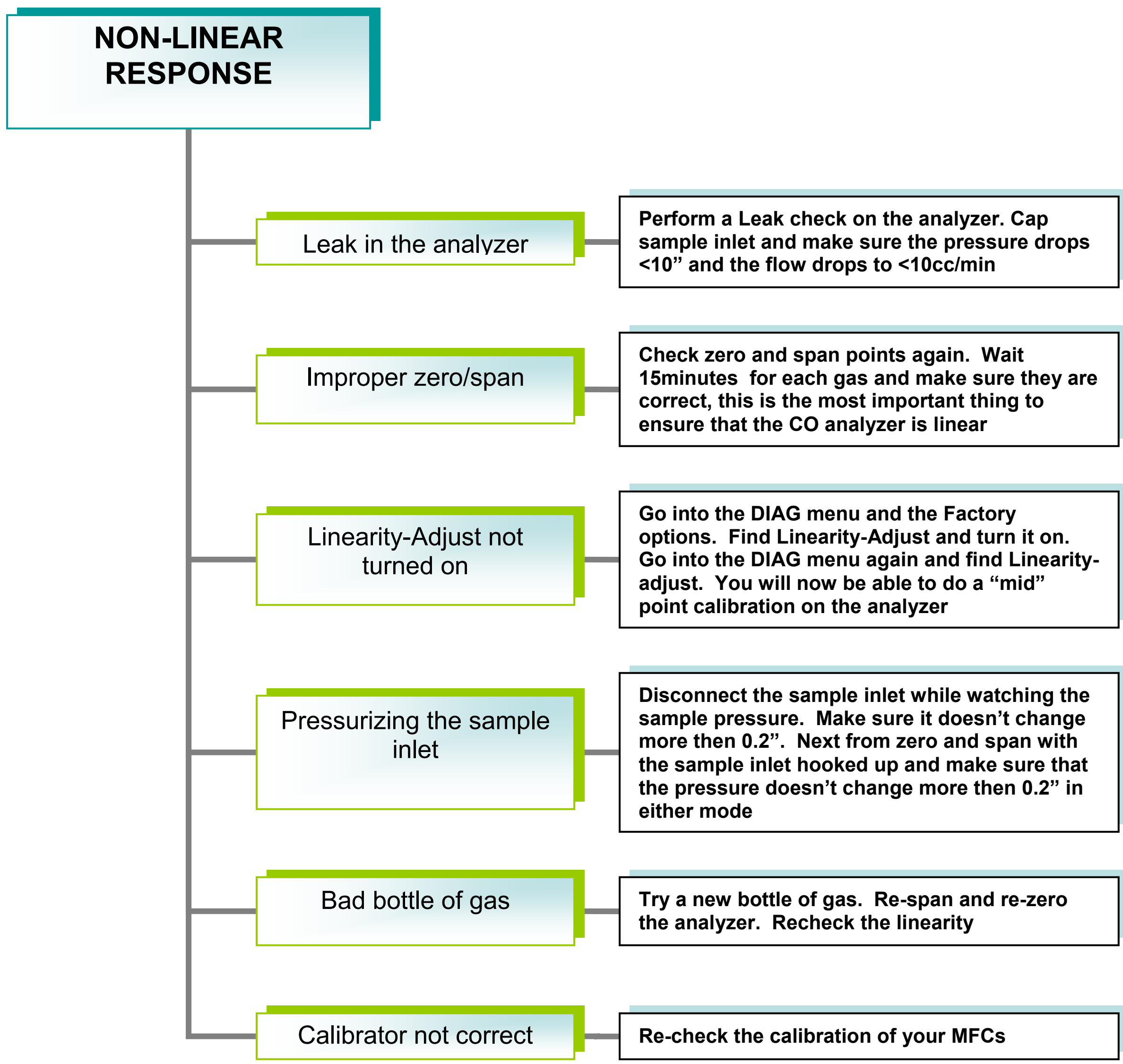
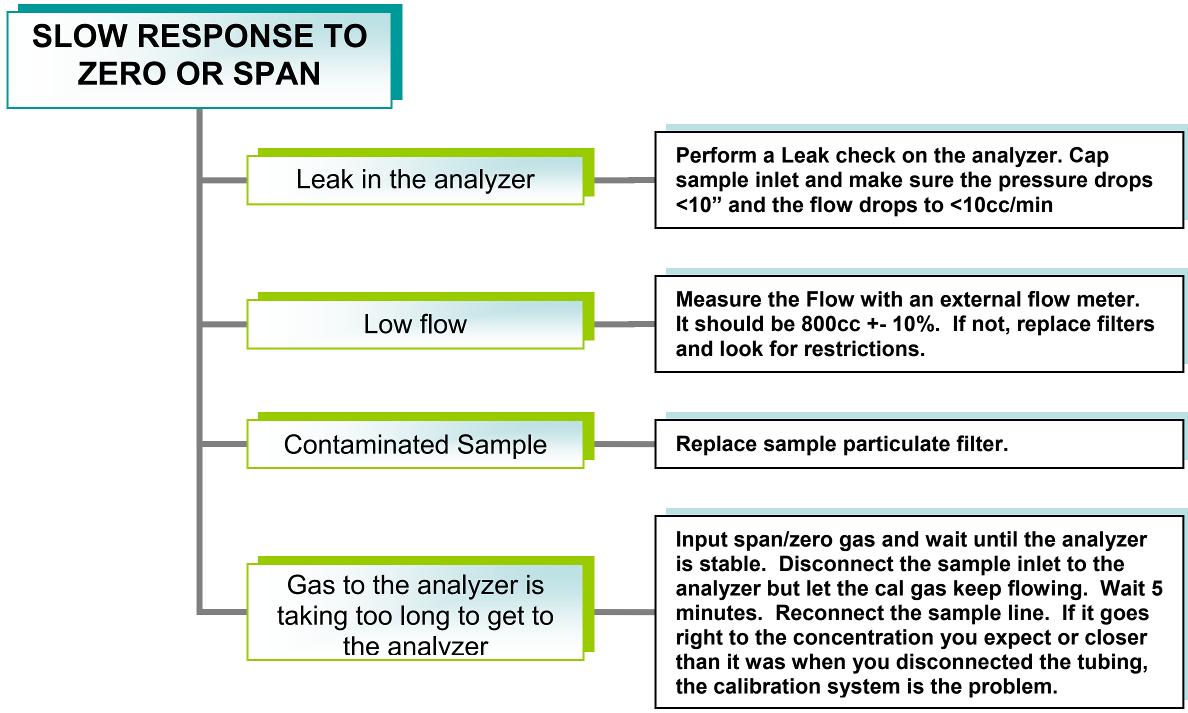
UNABLE TO ZERO (NO ZERO BUTTON)

Cause	Action
Leak in the analyzer	Perform a Leak check on the analyzer. Cap sample inlet and make sure the pressure drops <10" and the flow drops to <10cc/min
Internal Zero source depleted	Replace scrubber material and check with a known zero source
Dirty Sample tubing or sample filter	Replace tubing or sample filter
Zero Air Contaminated	Disconnect the sample inlet and see if the concentration goes negative, if it does, Switch Zero Air sources or replace scrubber material in current source of zero air
Bad Opto-Pickup	TP1, and TP2, on the opto-pickup board, should be perfect square waves as viewed with an oscilloscope. If they are not, the opto-pickup is most likely bad and needs to be replaced
Bad Detector	Replace the detector
Leaking Wheel	If the M/R ratio has been slowly drifting down over time and the zero slowly drifting up, it could be because the wheel has leaked out. 5 Year warranty part.
Measure and Reference read near 115mV	See the Section in this guide on this problem
Zero air Pressurized	Disconnect the sample inlet, if the sample pressures on the front panel changes by more then .2" the zero air needs to be vented better

UNABLE TO SPAN (NO SPAN BUTTON OR NO RESPONSE TO SPAN)

Leak in the analyzer	**Perform a Leak check on the analyzer. Cap sample inlet and make sure the pressure drops <10" and the flow drops to <10cc/min**
No Flow	**Make sure the pump is turning and there is suction from the vacuum side. Replace Filters. If still no flow, check for flow restrictions in the tubing.**
Wrong span CONC entered	**Make sure the proper span concentration is set in the CONC menu**
Measure and Reference read near 115mV	**See the Section in this guide on this problem**
Zero not correct	**Redo the zero making sure you give the analyzer enough time to become stable. If the zero is off a small amount it will cause the Span to be off by a large amount**
Dirty Sample tubing or	**Replace tubing or sample filter**
Bad Opto-Pickup	**TP2, and TP4, on the opto-pickup board, should be perfect square waves as viewed with an oscilloscope. If they are not the opto-pickup is most likely bad and needs to be replaced**
Bad Detector	**Replace the detector**
Leaking Wheel	**If the M/R ratio has been slowly drifting down over time and the zero slowly drifting up, it could be because the wheel has leaked out. 5 Year warranty part.**
Measure and Reference read near 115mV	**See the Section in this guide on this problem**


NON-LINEAR RESPONSE
Leak in the analyzer
Perform a Leak check on the analyzer. Cap sample inlet and make sure the pressure drops <10” and the flow drops to <10cc/min
Improper zero/span
Check zero and span points again. Wait 15minutes for each gas and make sure they are correct, this is the most important thing to ensure that the CO analyzer is linear
Linearity-Adjust not turned on
Go into the DIAG menu and the Factory options. Find Linearity-Adjust and turn it on. Go into the DIAG menu again and find Linearity-adjust. You will now be able to do a “mid” point calibration on the analyzer
Pressurizing the sample inlet
Disconnect the sample inlet while watching the sample pressure. Make sure it doesn’t change more then 0.2”. Next from zero and span with the sample inlet hooked up and make sure that the pressure doesn’t change more then 0.2” in either mode
Bad bottle of gas
Try a new bottle of gas. Re-span and re-zero the analyzer. Recheck the linearity
Calibrator not correct
Re-check the calibration of your MFCs


SLOW RESPONSE TO ZERO OR SPAN
Leak in the analyzer
Perform a Leak check on the analyzer. Cap sample inlet and make sure the pressure drops <10” and the flow drops to <10cc/min
Low flow
Measure the Flow with an external flow meter. It should be 800cc +- 10%. If not, replace filters and look for restrictions.
Contaminated Sample
Replace sample particulate filter.
Gas to the analyzer is taking too long to get to the analyzer
Input span/zero gas and wait until the analyzer is stable. Disconnect the sample inlet to the analyzer but let the cal gas keep flowing. Wait 5 minutes. Reconnect the sample line. If it goes right to the concentration you expect or closer than it was when you disconnected the tubing, the calibration system is the problem.

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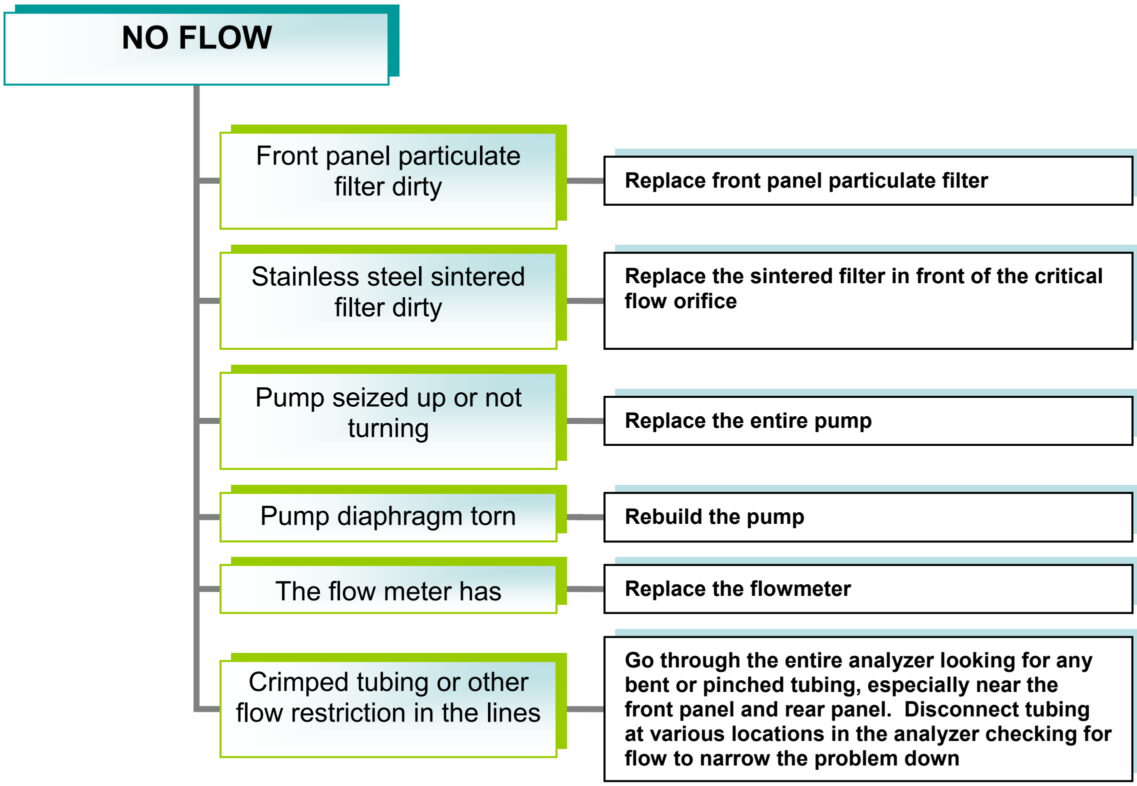
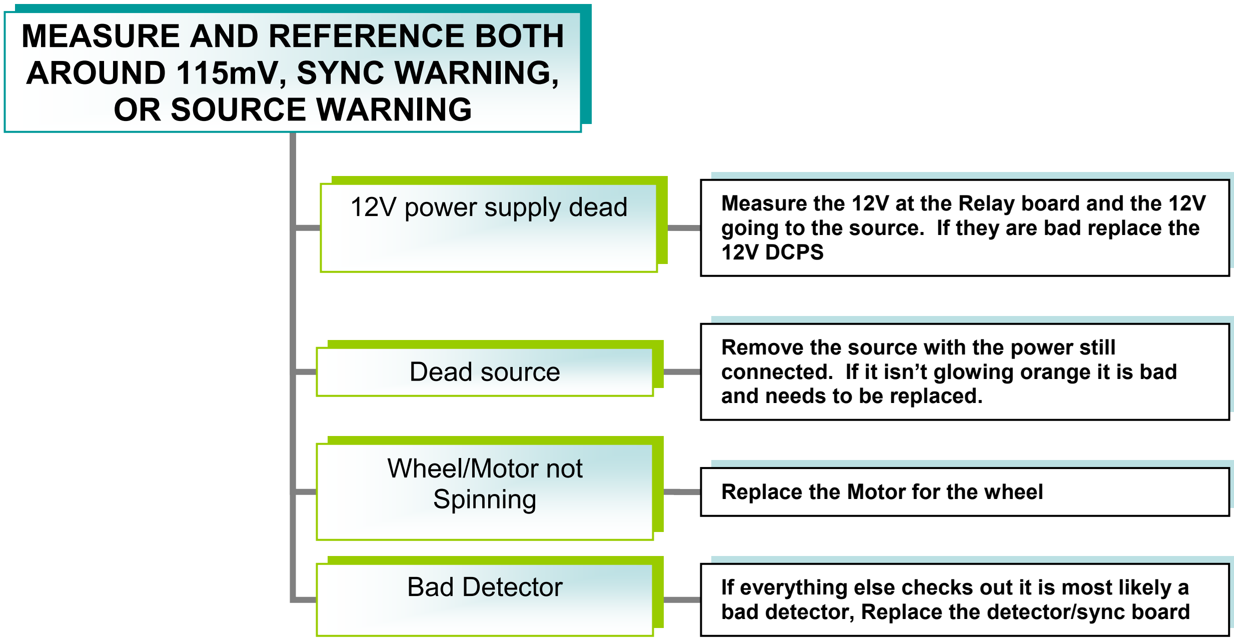

NO FLOW
Front panel particulate filter dirty
Replace front panel particulate filter
Stainless steel sintered filter dirty
Replace the sintered filter in front of the critical flow orifice
Pump seized up or not turning
Replace the entire pump
Pump diaphragm torn
Rebuild the pump
The flow meter has
Replace the flowmeter
Crimped tubing or other flow restriction in the lines
Go through the entire analyzer looking for any bent or pinched tubing, especially near the front panel and rear panel. Disconnect tubing at various locations in the analyzer checking for flow to narrow the problem down

NO ANALOG OR INCORRECT ANALOG OUTPUT

Outputs not properly calibrated	**Perform an analog output calibration. Refer to service note 03-020**
Output set for Voltage or current when it should be the other	**Look at the motherboard on the rear panel and J19, J21, and J23. Each connector that has a small circuit board about 2" by 1" is configured for current. If it has two shunts across the two left pins, or a small ½" by ½" circuit board, it is configured for Voltage.**
Bad motherboard	**Replace motherboard. (5 year warranty part)**
Noisy outputs	**Needs Analog Output Stabilizer board (KIT000214)**


MEASURE AND REFERENCE BOTH AROUND 115mV, SYNC WARNING, OR SOURCE WARNING
12V power supply dead
Measure the 12V at the Relay board and the 12V going to the source. If they are bad replace the 12V DCPS
Dead source
Remove the source with the power still connected. If it isn't glowing orange it is bad and needs to be replaced.
Wheel/Motor not Spinning
Replace the Motor for the wheel
Bad Detector
If everything else checks out it is most likely a bad detector, Replace the detector/sync board

ANY TEMPERATURE WARNING

Bad Relay

Toggle the heater on and off in the Signal I/O menu while measuring the AC voltage going to the heater. This should switch between 0V and line voltage. If the LED is turning on and off on the relay board, but the voltage isn't changing, the Relay is bad.

Bad Thermistor

Measure the Resistance of the thermistor in question. It should be around 25K ohms at room temperature. As the temperature goes up the resistance will go down. If the thermistor reads open or a short it is bad.

Bad Heater

Measure the Resistance of the heater. It should be less than 1K ohms in most cases. If it is open or shorted, it is bad.

User Notes:

7. SPECIFICATIONS

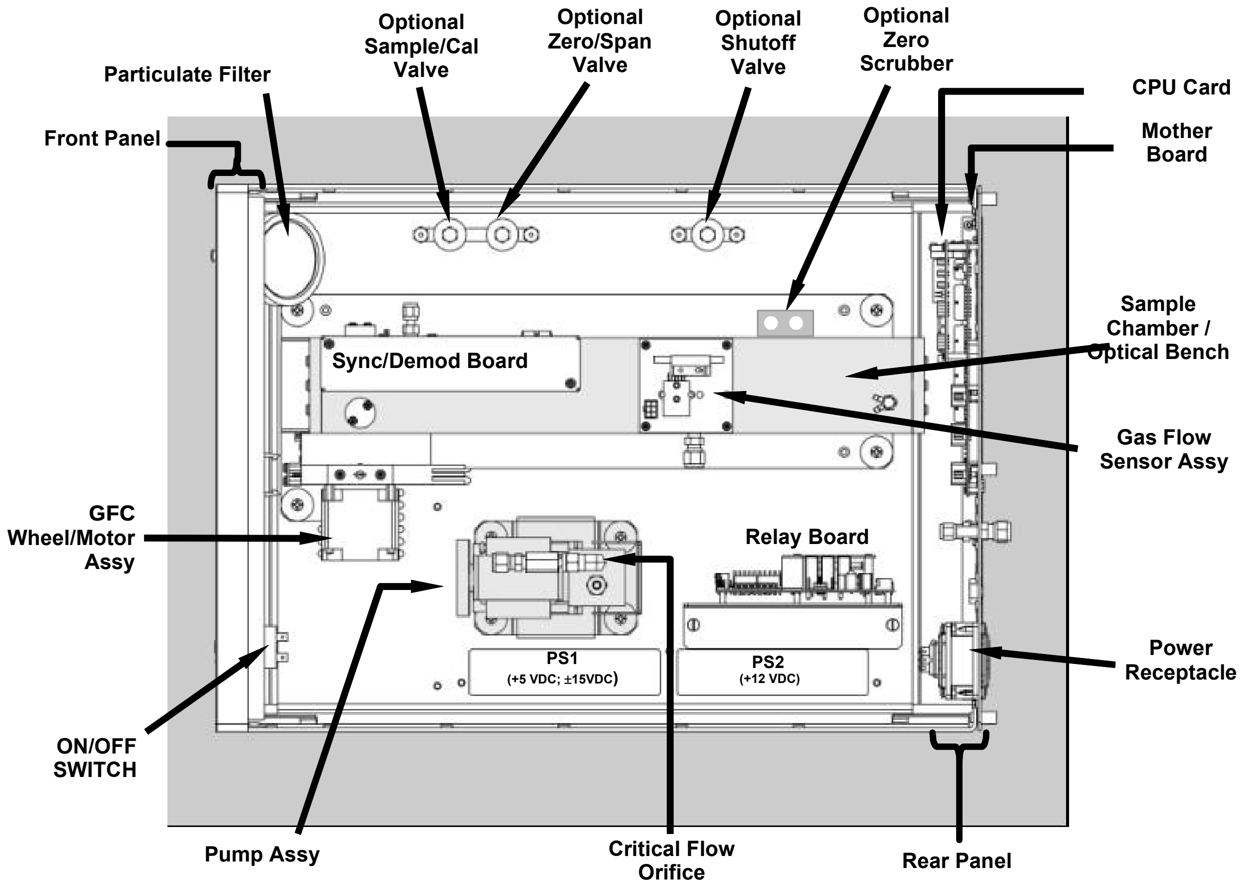
Model 300E Specifications

Ranges	M300E: Min: 0-1 ppm; Max: 0-1000 ppm of Full Scale (User selectable) M300EM: Min: 0-5 ppm; Max: 0-5000 ppm of Full Scale (User selectable)
Measurement Units	M300E: ppb, ppm, µg/m^3, mg/m^3 (user selectable) M300EM: ppm, mg/m^3 (user selectable)
Zero Noise	M300E: < 0.02 ppm RMS[1]; M300EM: ≤ 0.1 ppm RMS[1]
Span Noise	M300E:<0.5% of rdg RMS over 5ppm[1, 3]; M300EM:>0.5% of rdg RMS over 20ppm
Lower Detectable Limit	M300E: < 0.04 ppm[1]; M300EM: 0.2 ppm
Zero Drift (24 hours)	M300E: < 0.1 ppm[2]; M300EM: <0.5 ppm
Zero Drift (7 days)	M300E: < 0.2 ppm[2]; M300EM: <1.0ppm
Span Drift (24 hours)	< 0.5% of reading[2,4]
Span Drift (7 days)	< 1% of reading[2, 4]
Linearity	M300E: Better than 1% Full Scale[5]; M300EM: 0 - 3000 ppm: 1% full scale; 3000 - 5000 ppm: 2% full scale
Precision	M300E: 0.5% reading[1,5]; M300EM: 1.0% reading
Lag Time	10 sec[1]
Rise/Fall Time	<60 sec to 95%[1]
Sample Flow Rate	800 cm^3/min. ±10% O_2 Sensor option adds 120 cm^3/min to total flow though when installed
Temperature Range	5 - 40°C operating, 10 - 40°C EPA Equivalency
Humidity Range	0-95% RH, Non-Condensing
Temp Coefficient	< 0.05 % per °C (minimum 50 ppb/°C)
Voltage Coefficient	< 0.05 % per V
Dimensions (HxWxD)	7" x 17" x 23.5" (178 mm x 432 mm x 597 mm)
Weight	50 lb (22.7 kg)
AC Power	100V 50/60 Hz (3.25A), 115 V 60 Hz (3.0A), 220 – 240 V 50/60 Hz (2.5A)
Environmental Conditions	Installation Category (Over voltage Category) II Pollution Degree 2
Analog Outputs	4 user configurable outputs
Analog Output Ranges	M300E: All Outputs: 0.1V, 1V, 5V or 10V; M300EM: All Outputs: 100mV, 1V, 5V or 10V Three outputs convertible to 4-20 mA isolated current loop. All Ranges with 5% under/over-range
Analog Output Resolution	1 part in 4096 of selected full-scale voltage
Status Outputs	8 Status outputs from opto-isolators
Control Inputs	6 Control Inputs, 2 defined, 4 spare
Serial I/O	One (1) RS-232; One (1) RS-485 (2 connecters in parallel) Baud Rate : 300 - 115200
Alarm outputs (M300EM only)	2 opto-isolated alarms outputs with user settable alarm limits
Certifications	USEPA: Reference Method Number EQOA-0992-087 CE: EN61010-1:90 + A1:92 + A2:95, EN61326 - Class A

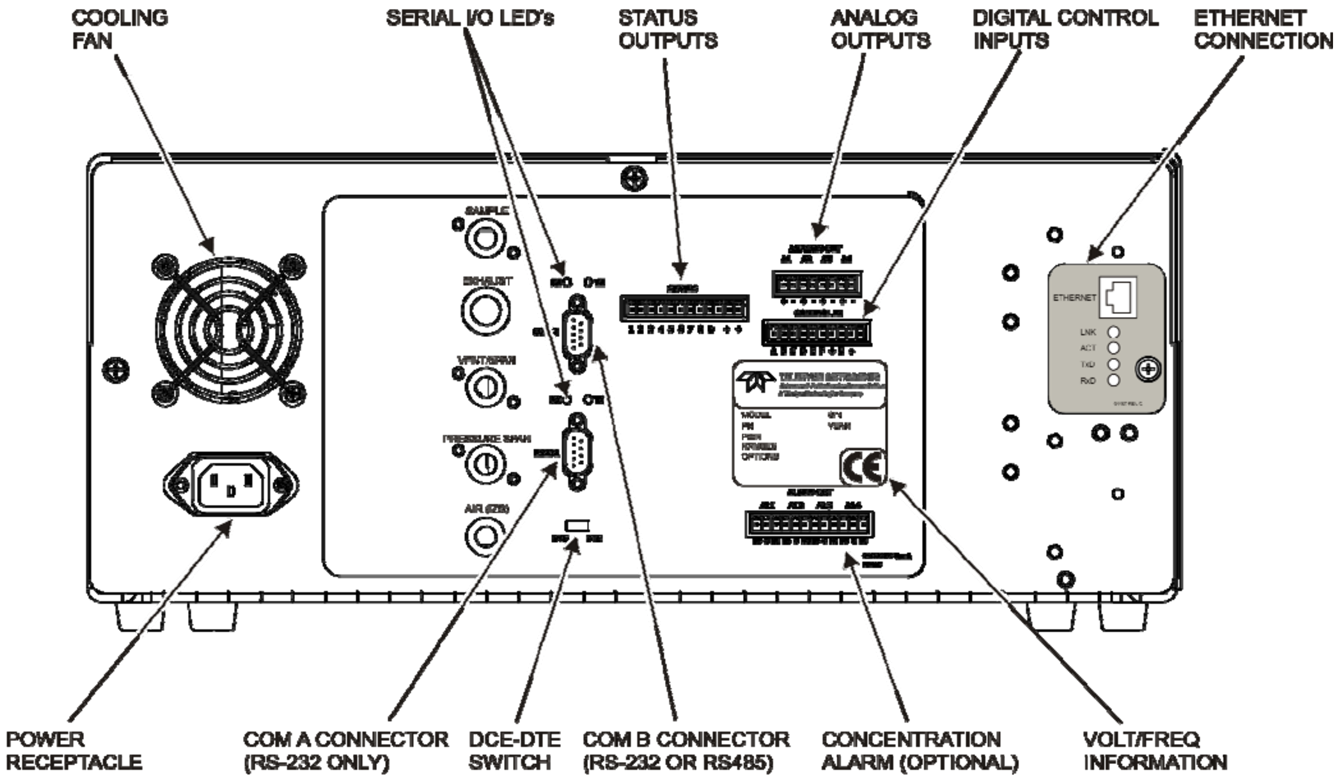
[1] As defined by the USEPA
[2] At constant temperature and voltage
[3] Or 0.2 ppm, whichever is greater
[4] Or 0.1 ppm, whichever is greater
[5] Above 10 ppm range, otherwise 0.2 ppm for lower ranges

8. MISCELLANEOUS DRAWINGS

M300E Assembly Layout



Rear Panel Connections



STATUS OUTPUTS

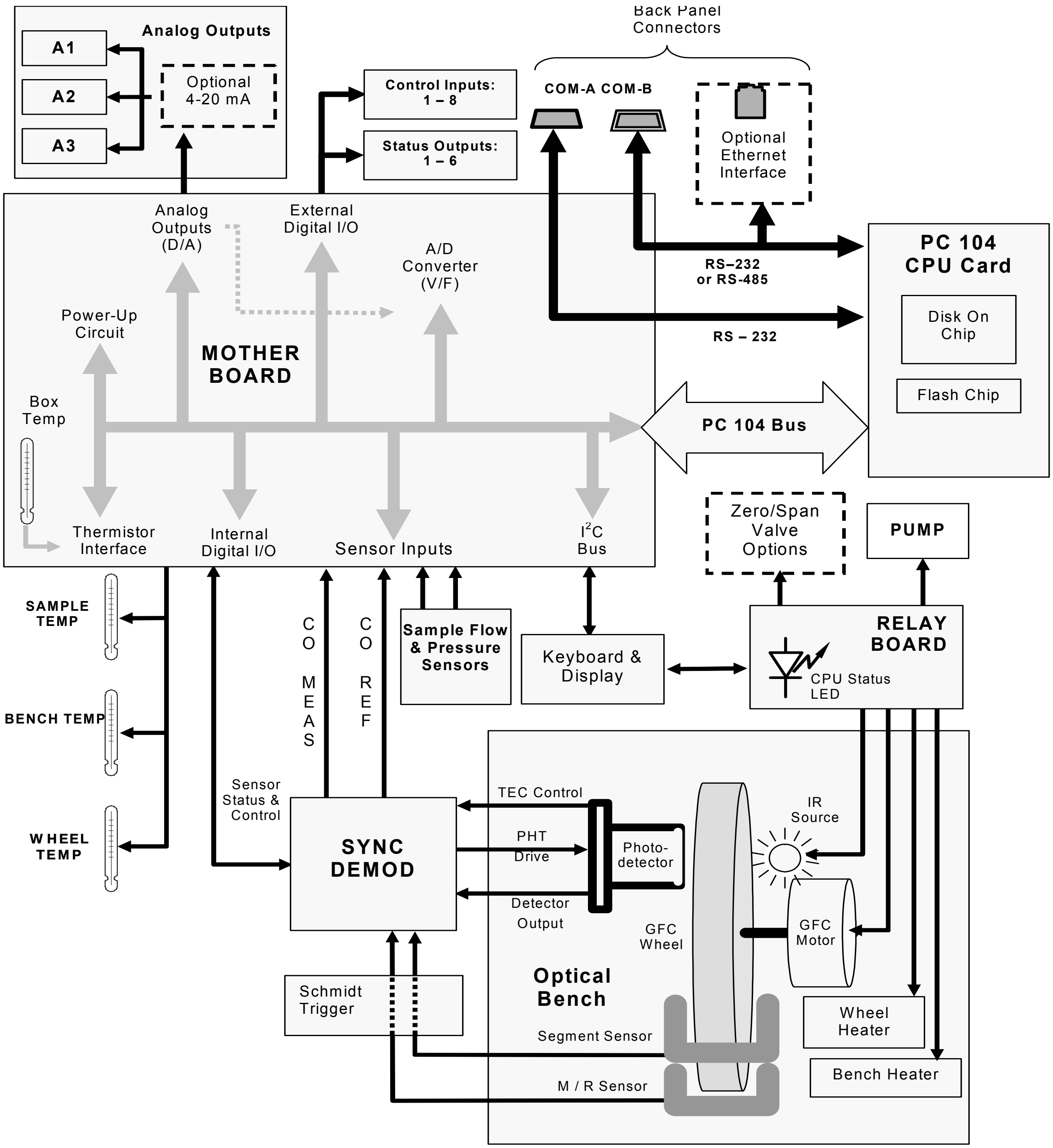
The Status Outputs report analyzer conditions via optically isolated NPN transistors, which sink up to 50 mA of DC current. These outputs can be used interface with devices that accept logic-level digital inputs, such as Programmable Logic Controllers (PLC's). Each Status bit is an open collector output that can withstand up to 40 VDC. All of the emitters of these transistors are tied together and available at the "-" PZN.
The status outputs are accessed via a 12-pin connector on the analyzer's rear panel labeled STATUS. The function of each pin is defined in.

Status Output Pin Assignments

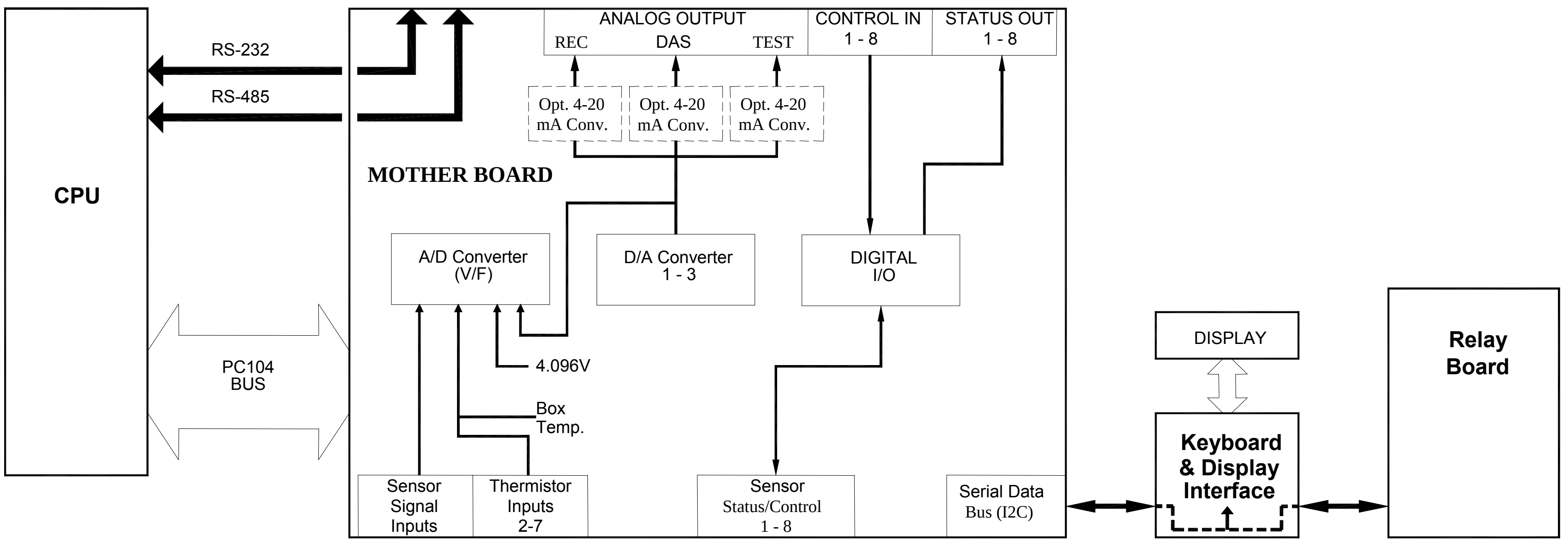
Output #	Status Definition	Condition
1	SYSTEM OK	On if no faults are present.
2	CONC VALID	On if CO concentration measurement is valid. If the CO concentration measurement is invalid, this bit is OFF.
3	HIGH RANGE	On if unit is in high range of **DUAL** or **AUTO** Range Modes.
4	ZERO CAL	On whenever the instruments ZERO point is being calibrated.
5	SPAN CAL	On whenever the instruments SPAN point is being calibrated.
6	DIAG MODE	On whenever the instrument is in DIAGNOSTIC mode.
7	SPARE	
8	SPARE	
D	EMITTER BUSS	The emitters of the transistors on pins 1-8 are bussed together.
+	DC POWER	+ 5 VDC
⏚	Digital Ground	The ground level from the analyzer's internal DC Power Supplies.

Electronic Operation

Block diagram of the major electronic components of the Model .300E.



E-Platform Basic Architecture



9. Other IR products

M300EU Trace CO

The model 300EU is a close derivative of the M300E/EM CO Analyzer, however its higher sensitivity requires some changes in its design and operation.

The primary differences between the M300EU and the M300E/EM analyzers are:

- **INTERFERANT REJECTION**: Periodically the sample gas stream is routed through an internal CO scrubber allowing the instrument to make a measurement of the sample gas completely free of CO; the measurement during this period is called the Auto-Reference (AREF). The AREF value is then subtracted from the sample measurement. This corrects for instrument zero drift, ambient temperature changes and changing CO_2 levels in the sample gas. This value is seen on the front panel as AUTO-ZERO RATIO
- **TEMPERATURE CONTROL:** The M300EU is very sensitive to changes in ambient temperature. To eliminate this sensitivity to temperature, the M300EU has heaters and blowers that maintain the optical bench, motherboard, and the CPU at a constant temperature of 46 degrees C.
- **SAMPLE GAS CONDITIONING:** A Nafion® drier is used to dry the sample and alleviate any effects from humidity changes in the sample gas.
- **IR OPTICS:** The objective and field mirrors on the optical bench are gold plated. This maximizes their reflectivity and increases the amount of IR light reaching the detector and improves the optical bench's signal-to-noise performance.
- **PNEUMATIC OPERATION**: The flow rate is higher. It has a 1.8LPM nominal flow rate. The flow sensor is rated to 6LPM.
- **SLOWER WARM-UP TIME**: The M300EU takes approximately 1 to 2 days of running in a temperature controlled environment for it to become nice and stable. Once stability has been achieved a span/zero can be performed.

Auto-Reference

The Auto-Reference feature in the M300EU is the largest difference, software wise, between the M300E. Throughout the different versions of the M300EU we have changed how the Auto-Reference operates. The current version uses the ACAL menu to control the Auto-Ref timing. This can be viewed by pressing SETUP ACAL. It should then display

SEQ 1> AUTO-REF, 0:04:00

From this screen press the SET button. In this menu there are a few different parameters that either affect the A-Ref or do nothing. Below is a list of each value and what it does or doesn't do.

TIMER ENABLE: The AREF frequency is determined by the timer and the delta time values in this menu. If this is disabled the A-Ref will not be performed.

STARTING DATE: This value should be some data before the current day. As long as this is true the analyzer will perform as desired.

STARTING TIME: As long as the Starting Date is correct, this value is irrelevant. The AREF will start at the top of the hour every four hours.

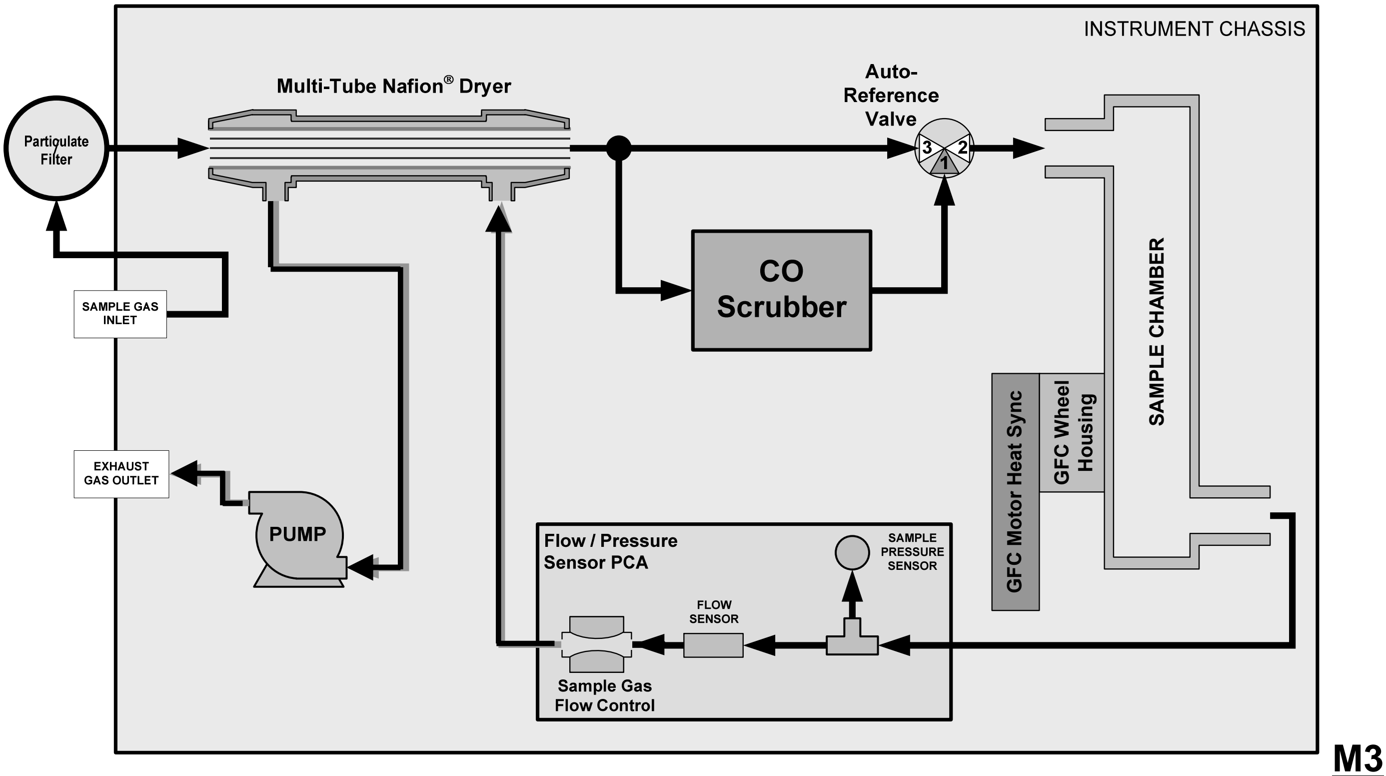
DELTA DAYS: This value is the amount of days between A-REF calibrations. This value is set defaulted at 0, as we recommend a 4 hour delay between A-REF calibrations.

DELTA TIME: This value is the amount of time between A-REF calibrations. The standard default value is 4 hours. If so desired this value can be increased or decreased. We do not recommend less then 1 hour as that will cause the analyzer to be in a calibration mode more then in sample mode.

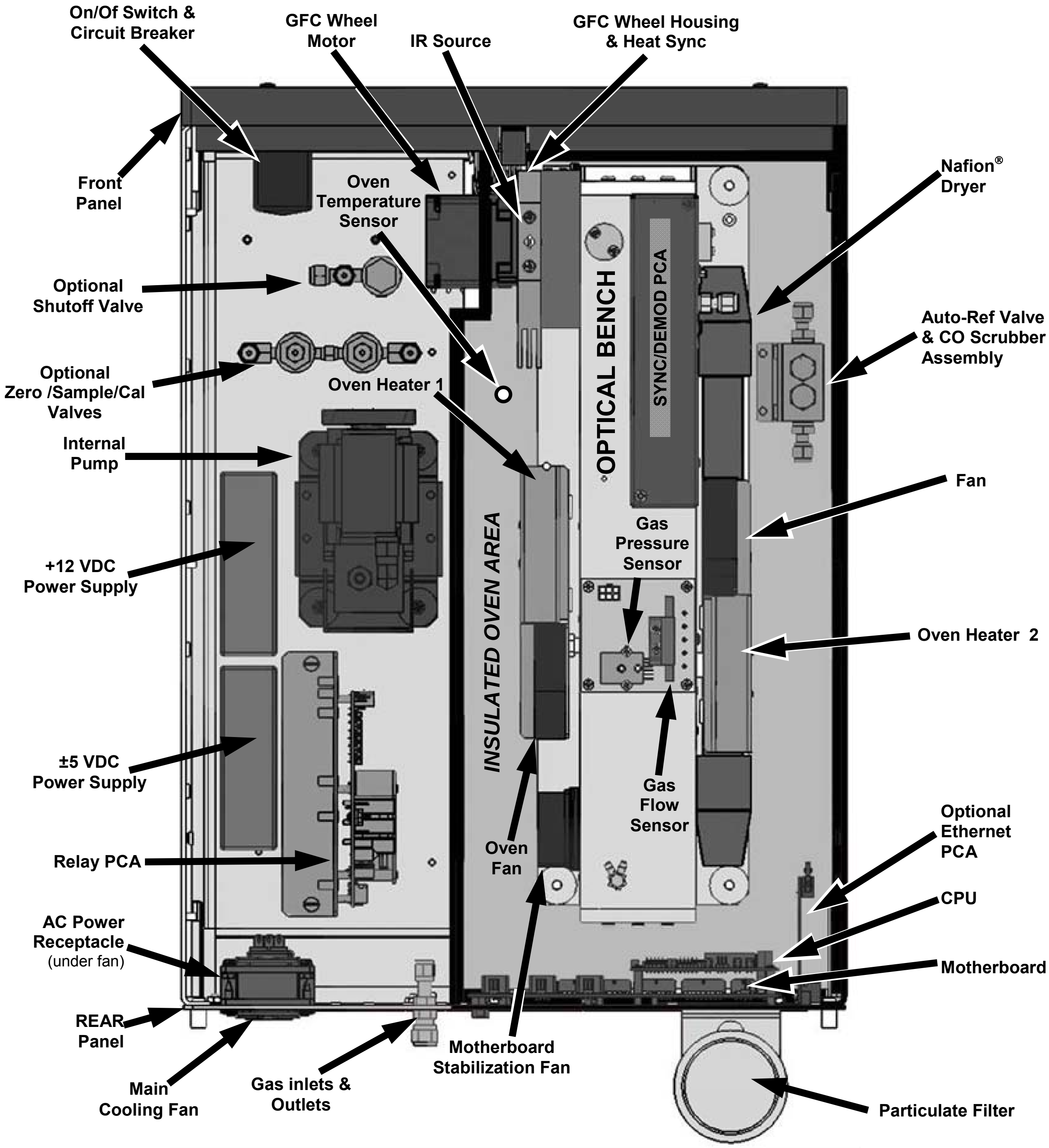
DURATION: This value is not used for anything and can be ignored. The actual duration for the A-REF is held in the VARS menu under ZERO_SAMPLES=. The duration of the A-ref can be changed by editing this number from its default of 1000 samples. 1000 samples gets about a 15-20 minutes A-Ref duration.

CALIBRATE: This value is not used for anything and can be ignored. As long as the timer is enabled the A-Ref value will perform correctly.

When performing a normal calibration on the analyzer, if your values do not appear to be correct or the analyzer is not having a good linearity it is recommend that you first perform an A-REF recalibration by pressing SETUP MORE AREF YES. This will reset the A-REF value and start a new calibration. After it has completed, about 30minutes, proceed with a normal Zero/Span calibration.



00EU Internal Gas Flow



M300EU Internal Layout

M300EU Basic Unit Specifications

Ranges	User selectable to any full scale range from 0-100 ppb to 0-100 ppm
Measurement Units	ppb, ppm, µg/m^3, mg/m^3 (user selectable)
Zero Noise	≤ 10 ppb RMS[1, 6]
Span Noise	< 0.5% of reading RMS over 5 ppm[1, 3]
Lower Detectable Limit	< 20 ppb[1]
Zero Drift (24 hours)	< 20 ppb[2]
Zero Drift (7 days)	< 20 ppb[2]
Span Drift (24 hours)	< 0.5% of reading [4]
Span Drift (7 days)	< 1% of reading [2 4]
Linearity	Better than 1% of Range[5]
Precision	0.5% reading[1, 5]
Lag Time	<10 sec[1]
Rise/Fall Time	<30 sec to 95%[1]
Sample Flow Rate	1800 cm^3/min. ± 20%
Temperature Range	15 - 35°C operating
Humidity Range	0-95% RH, Non-Condensing
Voltage Coefficient	< 0.05 % of reading per V
Dimensions (HxWxD)	7" x 17" x 23.5" (178 mm x 432 mm x 597 mm)
Weight	50 lb (22.7 kg)
AC Power	100V 50/60 Hz (3.25A), 115 V 60 Hz (3.0A), 220 – 240 V 50/60 Hz (2.5A)
Environmental Conditions	Installation Category (Over voltage Category) II Pollution Degree 2
Analog Outputs	Three (3) Outputs
Analog Output Ranges	100 mV, 1 V, 5 V, 10 V, 2-20 or 4-20 mA isolated current loop. All Ranges with 5% Under/Over Range
Analog Output Resolution	1 part in 4096 of selected full-scale voltage
Status Outputs	8 Status outputs from opto-isolators
Control Inputs	6 Control Inputs, 2 defined, 4 spare
I/O	One (1) RS-232; One (1) RS-485/RS-232/Ethernet Baud Rate : 300 - 115200
Certifications	CE: EN61010-1:90 + A1:92 + A2:95, EN61326 - Class A

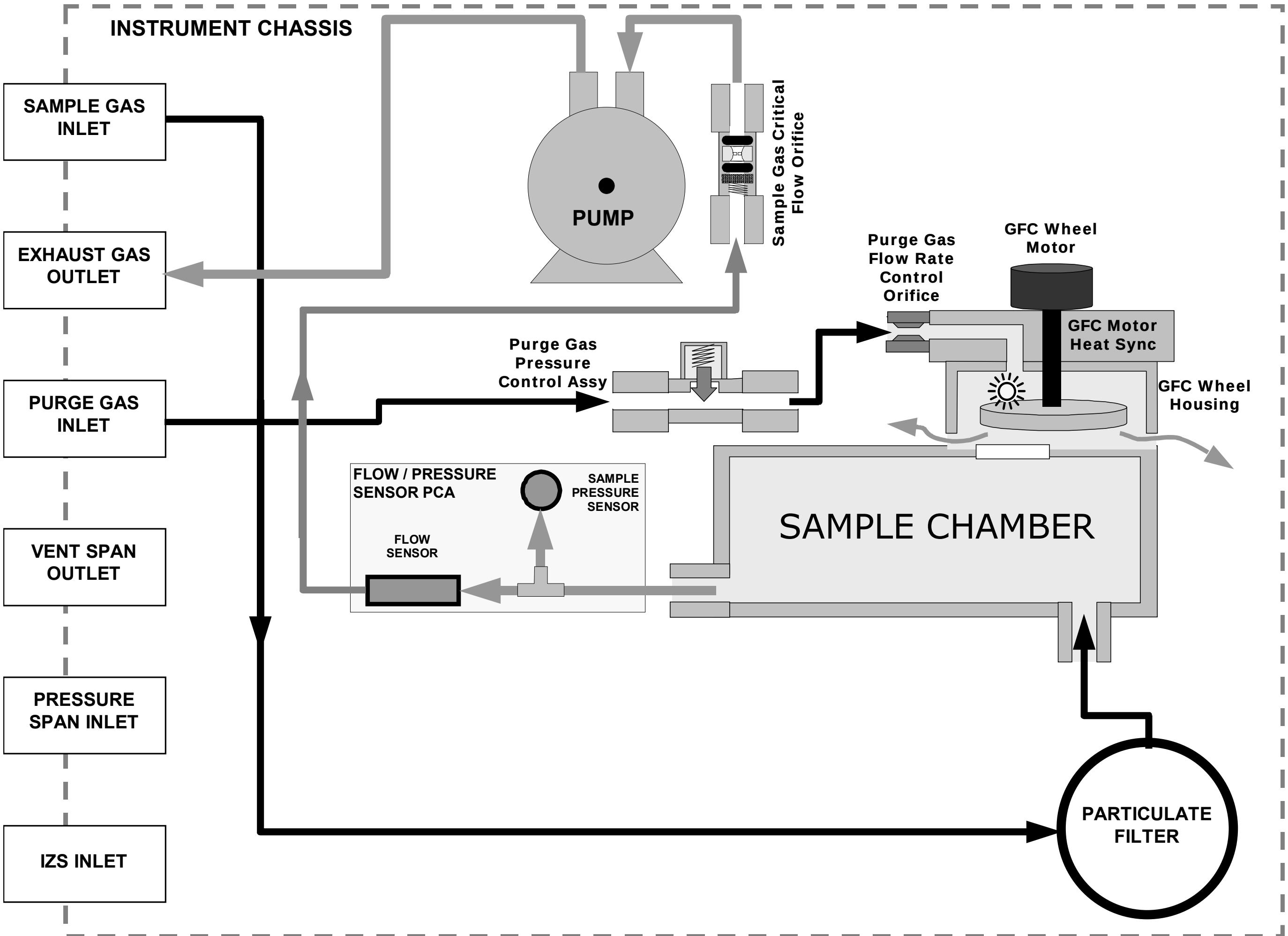
[1] As defined by the USEPA
[2] At constant temperature and voltage
[3] Or 10 ppb, whichever is greater
[4] Or 10 ppb, whichever is greater
[5] Above 1 ppm range, otherwise 20 ppb for lower ranges

M360E CO_2

The M360E CO_2 analyzer is almost exactly the same as the M300E covered in the pervious sections. The GFC wheel is filled with 90% N_2 and 10% CO_2 on the Reference side and 100% N_2 on the Measure side. With this gas concentration it makes the M/R ratio close to 2.5 when on zero air. The detector is also different as we now need to look at a different wavelength of IR light. This wavelength is 4.3µm.

Due to the high absorption co-efficient of CO_2, the optical bench in the M360E is quite different optically then the M300E. It uses a much smaller path length of 2.5 meters.

Another major difference about the M360E is the N_2 purge. Ambient CO_2 levels are typically near 400ppm. Due to such high levels of CO_2 being in the air it could possibly affect the readings. As the wheel itself is located outside of the sample path, it is possible to get ambient CO_2 between the wheel and the IR source affecting the CO_2 readings seen on the front panel, even though the concentration in the bench did not change. This is the reason we must have an N_2 purge hooked up to the analyzer. The N_2 purge flows a small amount of pure N_2 gas to the wheel housing and purges it of an ambient CO_2 that may affect the readings. This ensures that we will not be getting false readings due to changes in ambient CO_2.



M360E Pneumatic Diagram

M360E SPECIFICATIONS

Min/Max Range (Physical Analog Output)	In 1ppb increments from 50ppb to 2 000ppm, dual ranges or auto ranging
Measurement Units	ppb, ppm, µg/m^3, mg/m^3, %(user selectable)
Zero Noise	< 0.1 ppm (RMS)
Span Noise	< 1% of reading (RMS)
Lower Detectable Limit[1]	< 0.2 ppm[1]
Zero Drift (24 hours)	<0.25 ppm[1]
Zero Drift (7 days)	<0.5 ppm[1]
Span Drift (7 Days)	1% of reading above 50 PPM[1]
Linearity	1% of full scale
Precision	0.5% of reading
Temperature Coefficient	< 0.1% of Full Scale per oC
Voltage Coefficient	< 0.05% of Full Scale per V
Lag Time	10 sec
Rise/Fall Time	95% in <60 sec
Sample Flow Rate	800cm^3/min. ±10%
Temperature Range	5-40^{o}C
Humidity Range	0 - 95% RH, non-condensing
Dimensions H x W x D	7" x 17" x 23.5" (178 mm x 432 mm x 597 mm)
Weight, Analyzer	38 lbs. (17 kg); add 1 lbs (0.5 kg) for IZS
AC Power Rating	100 V, 50/60 Hz (3.25A); 115 V, 60 Hz (3.0 A); 220 – 240 V, 50/60 Hz (2.5 A)
Environmental	Installation category (over-voltage category) II; Pollution degree 2
Analog Outputs	Three (3) Outputs
Analog Output Ranges	0.1V, 1 V, 5 V, 10 V, 2-20 or 4-20 mA isolated current loop. All Ranges with 5% Under/Over Range
Analog Output Resolution	1 part in 4096 of selected full-scale voltage
Status Outputs	8 Status outputs - opto-isolated; including 2 alarm outputs
Control Inputs	6 Control Inputs, 3 defined, 3 spare
Serial I/O	One (1) RS-232; One (1) RS-485 Baud Rate : 300 – 115200: Optional Ethernet Interface
Certifications	CE: EN61010-1:90 + A1:92 + A2:95, EN61326 - Class A

[1] At constant temperature and voltage.

"E" Series IR Product Information

Model	M300E	M300EU	M300EM	M360E	M360EU	M320E
Gas	CO	CO	CO	CO2	CO2	N20
Filter Frequency	4.70uM	4.70uM	4.70uM	4.256uM	4.256uM	4.577uM
Bench Length	14M	14M	2.56M	2.56M	14M	2.56M
No. Of Passes	28	28	8	8	28	8
Ranges	1-1000	1-100	30-3000	10-2000	0.1-100	100-1000
Slots in Mask	12	12	12	12	12	12
Flow Rate	800	1800	800	800	800	800
Sync Demod Board/ Detector	KIT000178	KIT000283	KIT000179	KIT000180	KIT000180	KIT000277
Wheel	KIT000202	KIT000202	KIT000202	KIT000183	KIT000183	KIT000185
MR Ratio @ Zero	1.2 ± 0.5	1.2 ± 0.5	1.2 ± 0.2	2.5 ± 0.2	2.5 ± 0.2	1.4 ± 0.1
MEAS @ Zero	4500mv	4500mv	4500mv	4500mv	4500mv	4500mv

USER NOTES:

USER NOTES:

USER NOTES:

10. T SERIES ADDENDUM

Front panel, rear panel, and display

Getting Started

This section introduces you to the instrument components of the front and rear panel, which are unique to the T series analyzers.

Front Panel

Figure 10-1 shows the analyzer's front panel layout, followed by a close-up of the display screen in Figure 10-2, which is described in Table 10-1. The two USB ports on the front panel are provided for the connection of peripheral devices:

- plug-in mouse (not included) to be used as an alternative to the touchscreen interface
- thumb drive (not included) to upload new versions of software (contact T-API Customer Service for information).
- plug-in keyboard (not included) to reach the touchscreen display calibration menu

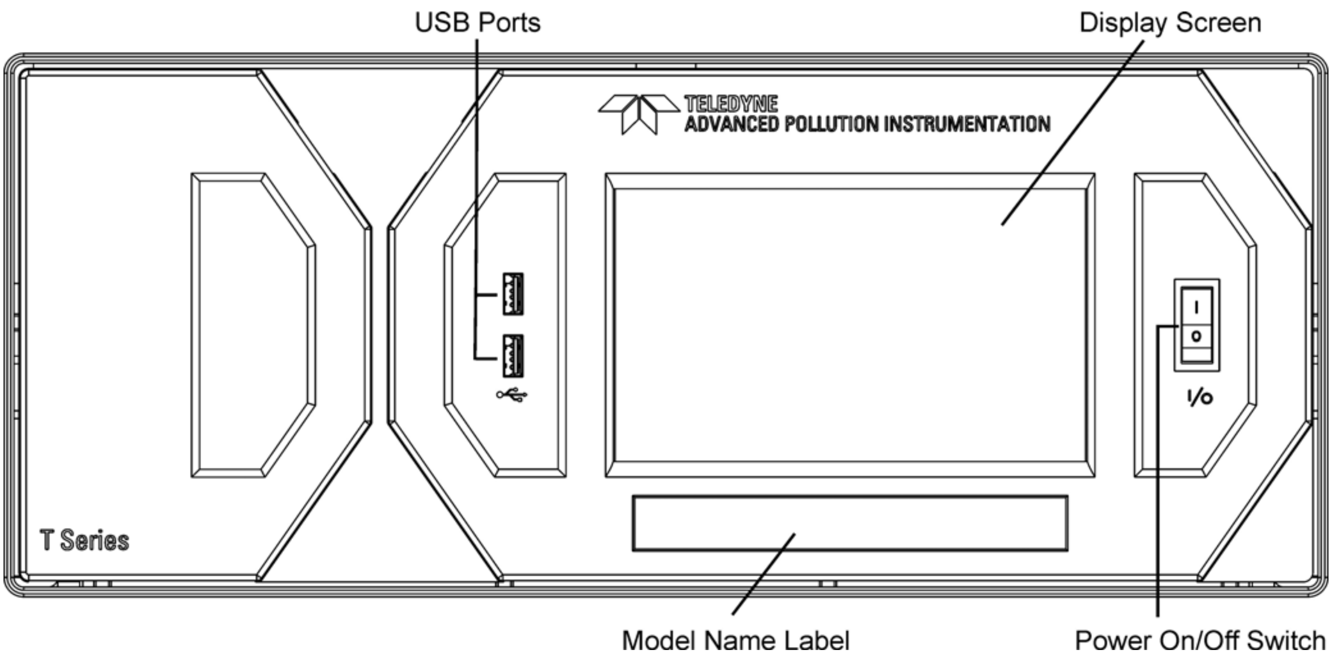


Figure 10-1: Front Panel Layout

Figure 10-2: Display Screen and Touch Control

The front panel liquid crystal display screen includes touch control. Upon analyzer start-up, the screen shows a splash screen and other initialization indicators before the main display appears, similar to Figure 9-2 above (may or may not display a Fault alarm). The lights on the display screen indicate the Sample, Calibration and Fault states; also on the screen is the gas concentration field (Conc), which displays real-time readouts for the primary gas and for the secondary gas if installed. The display screen also shows what mode the analyzer is currently in, as well as messages and data (Param). Along the bottom of the screen is a row of touch control buttons; only those that are currently applicable will have a label. Table 10-1 provides detailed information for each component of the screen.

ATTENTION

COULD DAMAGE INSTRUMENT

Do not use hard-surfaced instruments, such as pens, to touch the control buttons.

Table 10-1: Display Screen and Touch Control Description

Field	Description/Function			
Status	Lights indicating the states of Sample, Calibration and Fault, as follows:			
	Name	Color	State	Definition
	SAMPLE	Green	Off	Unit is not operating in sample mode, DAS is disabled.
			On	Sample Mode active; Front Panel Display being updated; DAS data being stored.
			Blinking	Unit is operating in sample mode, front panel display being updated, DAS hold-off mode is ON, DAS disabled
	CAL	Yellow	Off	Auto Cal disabled
			On	Auto Cal enabled
			Blinking	Unit is in calibration mode
	FAULT	Red	Off	No warnings exist
			Blinking	Warnings exist
Conc	Displays the actual concentration of the sample gas currently being measured by the analyzer in the currently selected units of measure			
Mode	Displays the name of the analyzer's current operating mode			
Param	Displays a variety of informational messages such as warning messages, operational data, test function values and response messages during interactive tasks.			
Control Buttons	Displays dynamic, context sensitive labels on each button, which is blank when inactive until applicable.			

Figure 10-3 shows how the front panel display is mapped to the menu charts illustrated in this manual. The Mode, Param (parameters), and Conc (gas concentration) fields in the display screen are represented across the top row of each menu chart. The eight touch control buttons along the bottom of the display screen are represented in the bottom row of each menu chart.

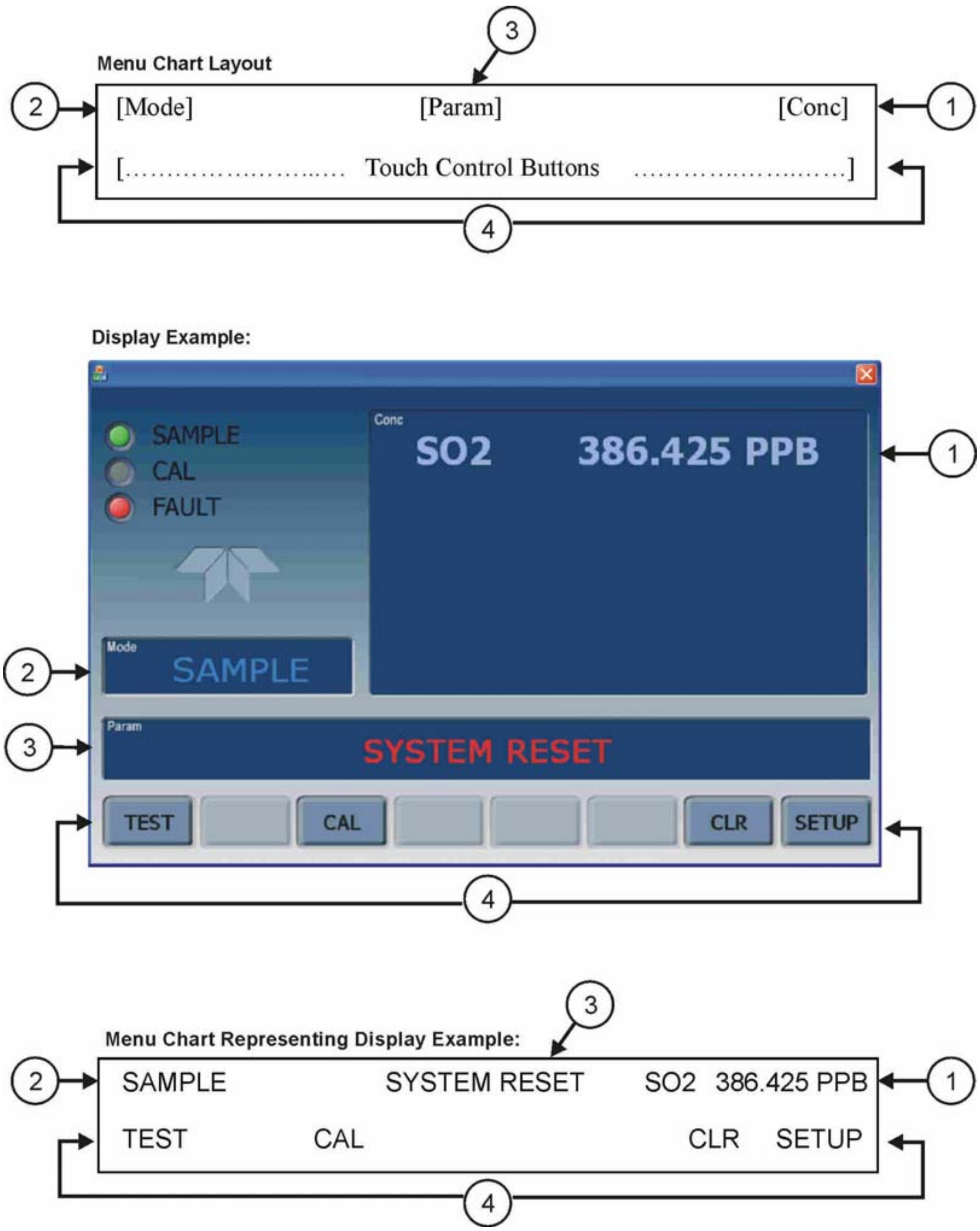


Figure 10-3: Display/Touch Control Screen Mapped to Menu Charts

Front Panel/Display Interface

Users can input data and receive information directly through the front panel touch-screen display. The LCD display is controlled directly by the CPU board. The touchscreen is interfaced to the CPU by means of a touchscreen controller that connects to the CPU via the internal USB bus and emulates a computer mouse.

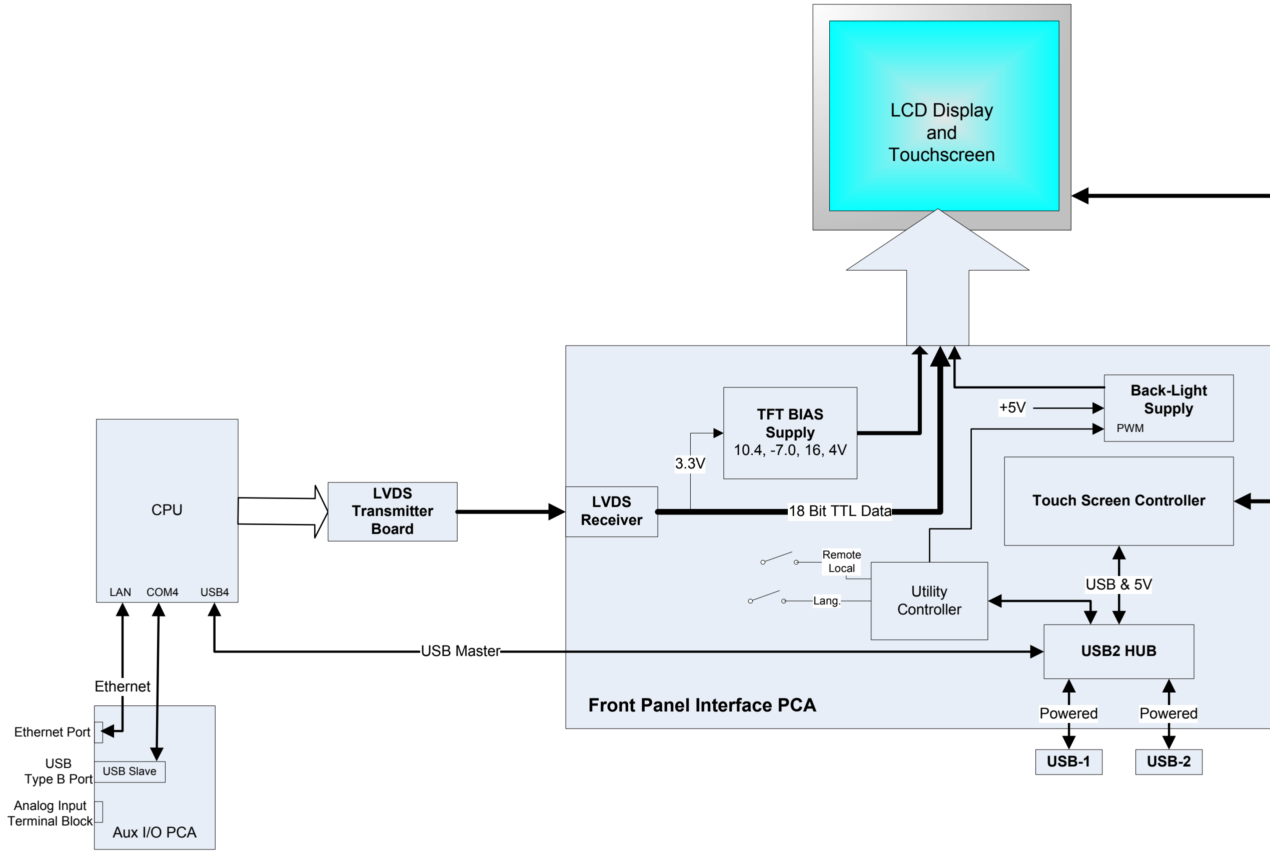


Figure10-4: Front Panel and Display Interface Block Diagram

LVDS Transmitter Board

The LVDS (low voltage differential signaling) transmitter board converts the parallel display bus to a serialized, low voltage, differential signal bus in order to transmit the video signal to the LCD interface PCA.

Front Panel Interface PCA

The front panel interface PCA controls the various functions of the display and touchscreen. For driving the display it provides connection between the CPU video controller and the LCD display module. This PCA also contains:

- power supply circuitry for the LCD display module
- a USB hub that is used for communications with the touchscreen controller and the two front panel USB device ports
- the circuitry for powering the display backlight (current driven)

Rear panel

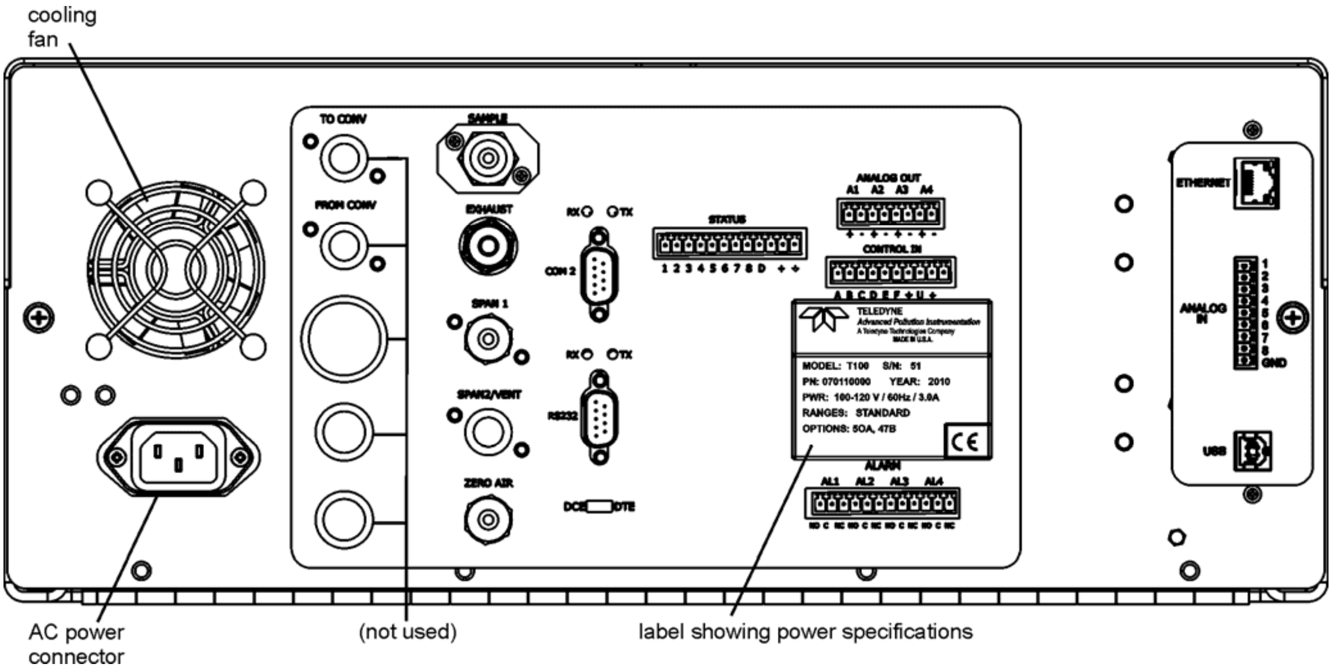


Figure 10-5: Rear Panel Layout

Table10-2 provides a description of new components on the rear panel.

Table10-2: Rear Panel Description

Component	Function
ANALOG IN	Option for external voltage signals from other instrumentation and for logging these signals
USB	Connector for direct connection to personal computer, using USB cable.

Connecting Analog Inputs (Option)

The Analog In connector is used for connecting external voltage signals from other instrumentation (such as meteorological instruments) and for logging these signals in the analyzer's internal DAS. The input voltage range for each analog input is 0-10 VDC.

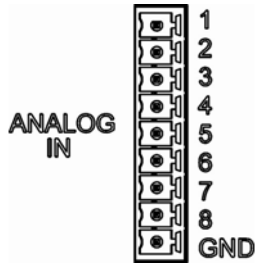


Figure 9-6: Analog In Connector

Pin assignments for the Analog In connector are presented in Table 10-3.

Table 10-3: Analog Input Pin Assignments

PIN	DESCRIPTION	DAS PARAMETER[1]
1	Analog input # 1	AIN 1
2	Analog input # 2	AIN 2
3	Analog input # 3	AIN 3
4	Analog input # 4	AIN 4
5	Analog input # 5	AIN 5
6	Analog input # 6	AIN 6
7	Analog input # 7	AIN 7
8	Analog input # 8	AIN 8
GND	Analog input Ground	N/A

USB Connection (Option)

For direct communication between the analyzer and a PC, connect a USB cable between the analyzer and desktop or laptop USB ports. (If this option is installed, the **COM2** port can only be used for Multidrop communication).The baud rate of the PC and the analyzer must match.

Calibration & update procedures
Display Calibration

The touchscreen display for the T series analyzer can be calibrated for the user's individual touch. To calibrate the display, you will need a USB keyboard. With the keyboard plugged into either USB port on the front panel, power off the instrument and then re-power.

A Teledyne logo will appear and flash, wait until a logo appears again with the words **System Booting** and a loading bar appear below the logo, and hold down the left shift and left control key on the keyboard throughout the rest of the boot up. This may take several minutes to reach the destination screen.

Once the screen becomes solid blue and a mouse curser appears on the center of the display, release the left shift and left control keys. A red and white target will appear near the center of the screen. Press the target to start the calibration. The target will now appear in a different location. Press and hold each target following the instructions on the display until you are asked to hit either ACCEPT or CANCEL. Hit accept to accept the changes or cancel to decline the changes. After you hit accept, remove the keyboard and re-power the instrument.

Analog Input Calibration

Analog I/O Configuration for Analog In

Table 10-4: DIAG - Analog I/O Functions (Example functions for a T100, AOUTS may vary)

SUB MENU	FUNCTION
AOUTS CALIBRATED:	Shows the status of the analog output calibration (YES/NO) and initiates a calibration of all analog output channels.
CONC_OUT_1	Sets the basic electronic configuration of the A1 analog output (SO_2). There are three options: • **RANGE:** Selects the signal type (voltage or current loop) and full scale level of the output. • **REC_OFS:** Allows setting a voltage offset, not available when RANGE is set to Current Loop (**CURR**). • **AUTO_CAL:** Performs the same calibration as AOUT CALIBRATED, but on this one channel only. NOTE: Any change to RANGE or REC_OFS requires recalibration of this output.
CONC_OUT_2	Same as for CONC_OUT_1 but for analog channel 2 (SO_2)
TEST OUTPUT	Same as for CONC_OUT_1 but for analog channel 4 (TEST)
CONC_OUT_3	(Not available in the analyzer's standard configuration; applies when optional sensor installed).
AIN CALIBRATED	Shows the calibration status (YES/NO) and initiates a calibration of the analog input channels.
XIN1 . . . **XIN8**	For each of 8 external analog inputs channels, shows the gain, offset, engineering units, and whether the channel is to show up as a Test function.

AIN Calibration

This is the sub-menu to conduct the analog input calibration. This calibration should only be necessary after major repair such as a replacement of CPU, motherboard or power supplies. Navigate to the **ANALOG I/O CONFIGURATION MENU** from the DIAG Menu, then press:

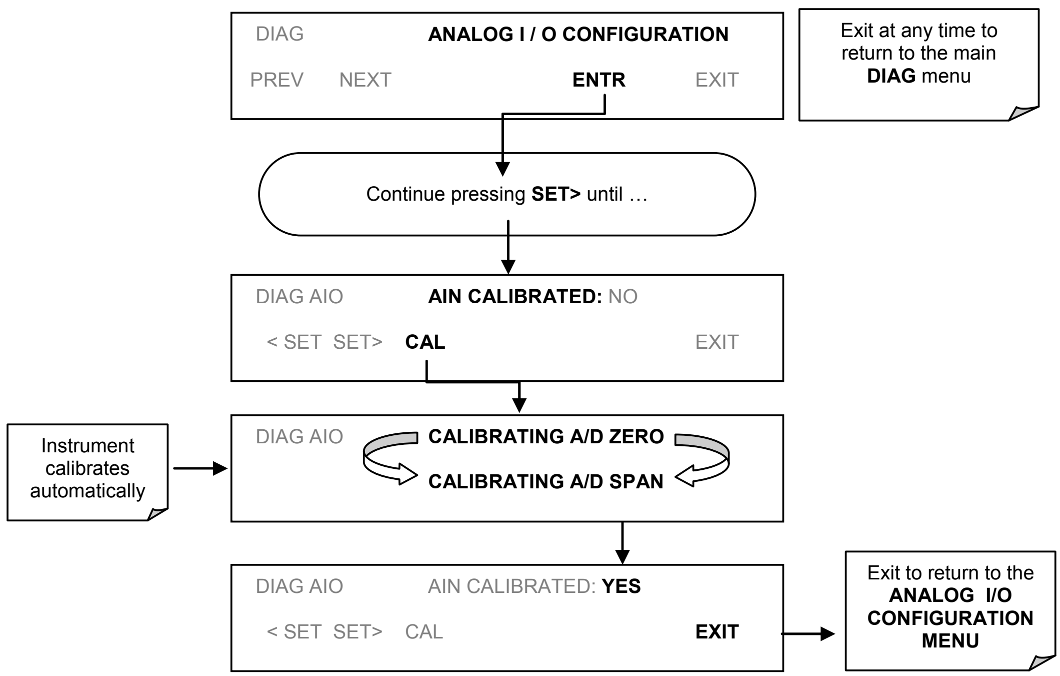


Figure 10-7: DIAG – Analog I/O Configuration – AIN Calibration

Analog Inputs (XIN1…XIN8) Option Configuration

To configure the analyzer's optional analog inputs define for each channel:

- gain (number of units represented by 1 volt)
- offset (volts)
- engineering units to be represented in volts (each press of the touchscreen button scrolls the list of alphanumeric characters from A-Z and 0-9)
- whether to display the channel in the Test functions

To adjust settings for the Analog Input option parameters press:

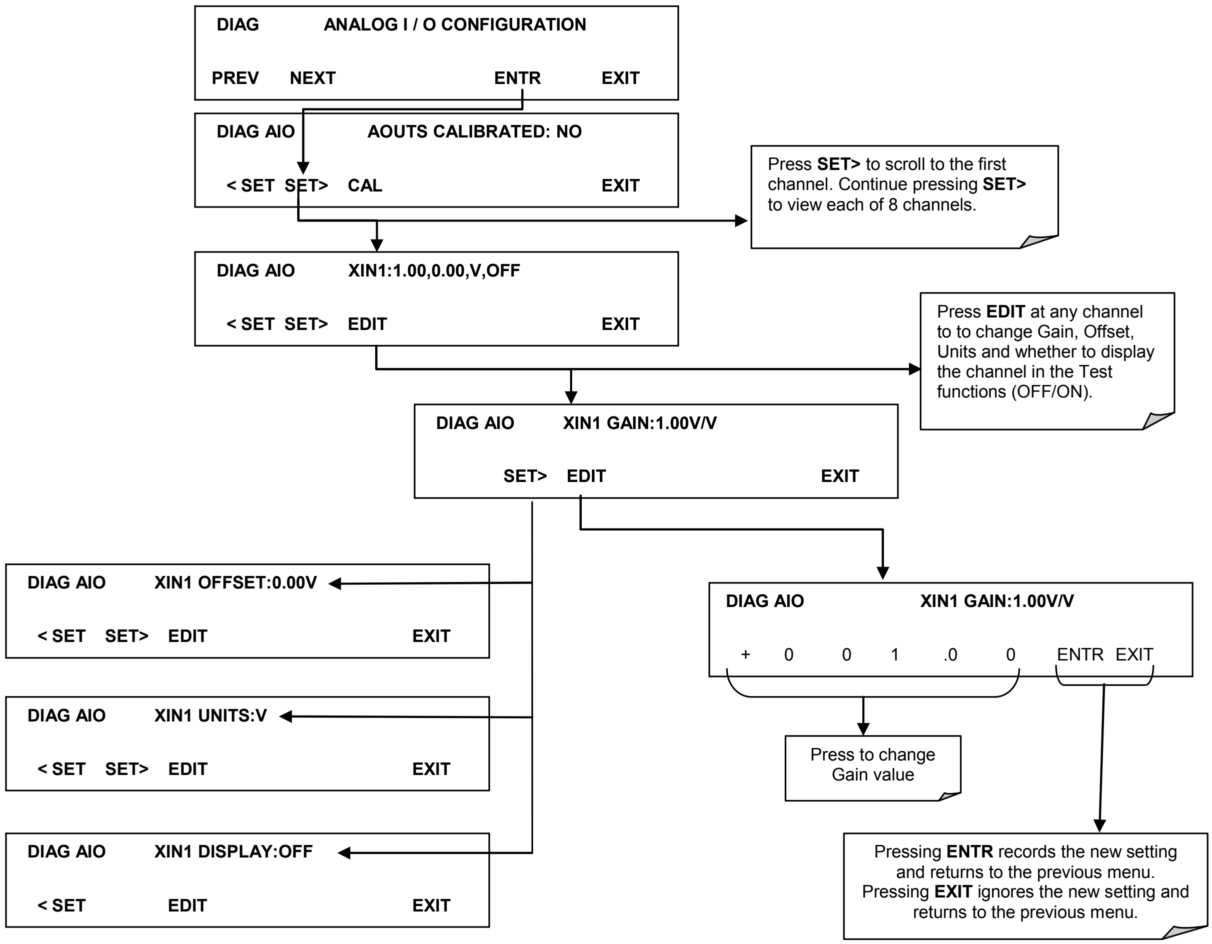


Figure 10-8 DIAG – Analog Inputs (Option) Configuration Menu

USB Configuration

After connecting a USB cable between your PC and the instrument, ensure their baud rates match (change the baud rate setting for either your PC's software or the instrument). COM2 is the default setup menu for USB configuration.

Also, while there are various communication modes available, the default settings are recommended for USB, except to change the baud rate if desired.

Your computer may need the correct drivers in order to communicate via the USB port. These drivers will be available on TAPI's website in the near future. You can contact API customer service if you need the drivers and instructions before then. Once the drivers are installed, the instrument's USB port should work as a standard COM2 port.

Firmware Updates via USB

The T series analyzers can receive firmware updates using a flash drive and the USB ports on the front panel. To update the firmware, locate the file you want to use for the update, and rename it to "update.exe" and copy to the flash drive. This file must not be in a folder on your flash drive in order to be recognized by the T series instrument. Plug in the flash drive and the instrument will give you a popup message with the model the firmware is intended for and the version of firmware, the analyzer will ask if you wish to continue, press yes to continue.

Warning, the instrument will load any recognizable firmware you tell it to regardless of if it is intended for that instrument or not. Double check the firmware model and version before selecting continue.

Troubleshooting faults

Touch-screen Interface

Verify the functioning of the touch screen by observing the display when pressing a touch-screen control button. Assuming that there are no wiring problems and that the DC power supplies are operating properly, but pressing a control button on the touch screen does not change the display, any of the following may be the problem:

- The touch-screen controller may be malfunctioning.
- The internal USB bus may be malfunctioning.

You can verify this failure by logging on to the instrument using APICOM or a terminal program. If the analyzer responds to remote commands and the display changes accordingly, the touch-screen interface may be faulty.

LCD Display Module

Verify the functioning of the front panel display by observing it when power is applied to the instrument. Assuming that there are no wiring problems and that the DC power supplies are operating properly, the display screen should light and show the splash screen and other indications of its state as the CPU goes through its initialization

Touch-screen not working correctly

If you experience problems where the display reacts to touch in a different location to where you are pressing, you may need to re-calibrate the touch-screen. Also, if you are in the touch-screen calibration mode and press cancel at the end of the calibration sequence, you will loose the previous calibration and the display will be mis-calibrated. To correct this, follow the calibration procedure in the Display Calibration section.

Diagrams and schematics

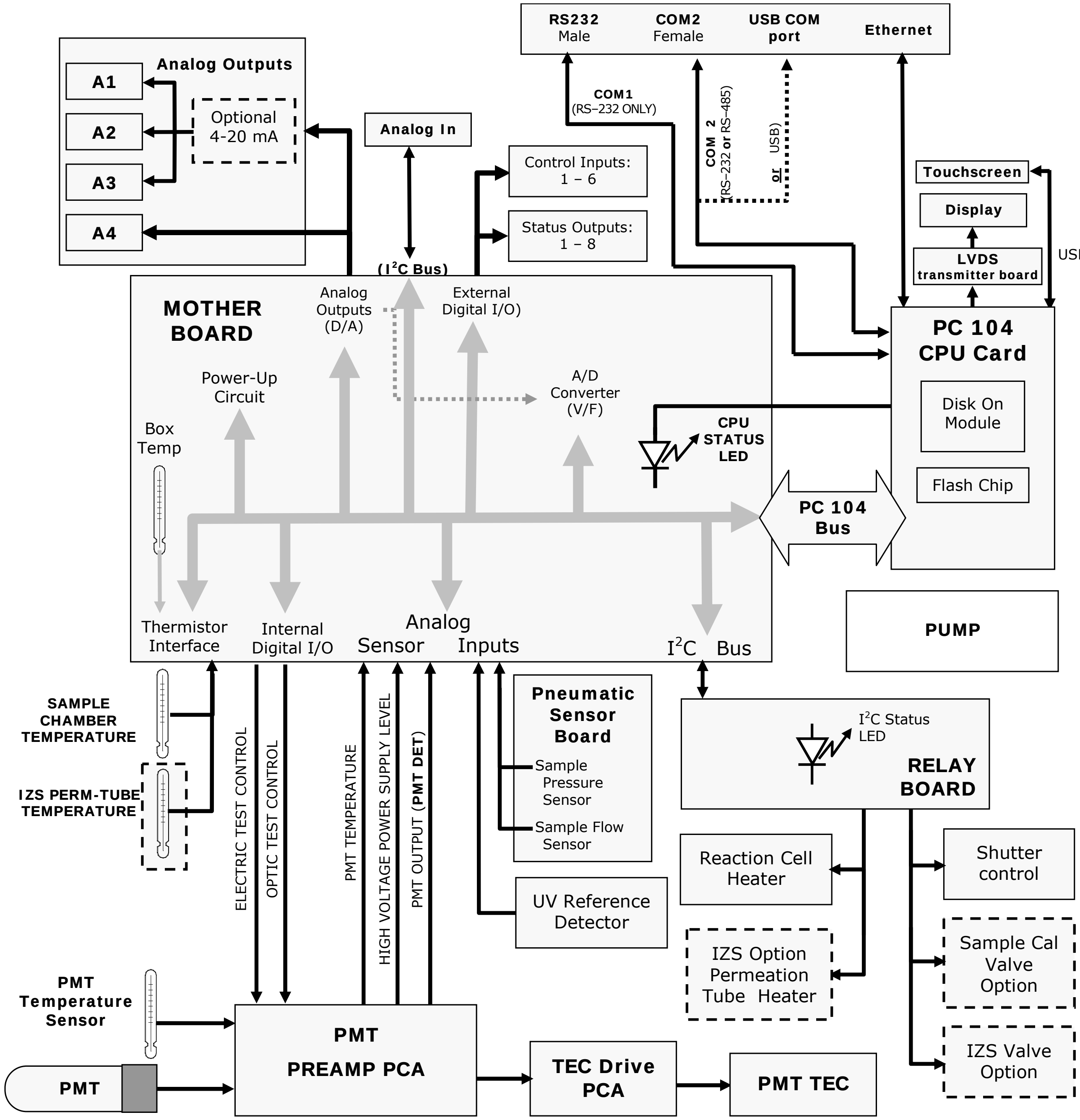


FIGURE 10-9, EXAMPLE OF AN ELECTRONIC BLOCK DIAGRAM (T100)

“E” series compatibility

Incompatible components

The following components are not compatible between E series and T series analyzers:

CPU
Multidrop
Display and Keyboard components
Ethernet
USB
Analog Inputs