TRAINING MANUAL

MODEL 700E / T700
DYNAMIC DILUTION CALIBRATOR

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06080 Rev. C
DCN 6465
08 May2012

TABLE OF CONTENTS

1. PRINCIPLE OF OPERATION

1. THEORY OF OPERATION

1.1. BASIC PRINCIPLES OF DYNAMIC DILUTION CALIBRATION

The M700E Dynamic Dilution Calibrator generates calibration gas mixtures by mixing bottled source gases of known concentrations with a diluent gas (zero air). Using several mass flow controllers (MFC's) the M700E calibrator creates exact ratios of diluent and source gas by controlling the relative rates of flow of the various gases, under conditions where the temperature and pressure of the gasses being mixed is known (and therefore the density of the gases).
The CPU calculates both the required source gas and diluent gas flow rates and controls the corresponding mass flow controllers by the following equation.

Equation 1-1

$$C_f = C_i \times \frac{GAS_{flow}}{Totalflow}$$

WHERE:

C_f = final concentration of diluted gas

C_i = source gas concentration

GAS_{flow} = source gas flow rate

$Totalflow$ = the total gas flow through the calibrator

Totalflow is determined as:

Equation 1-2a

$$\boldsymbol{TOTALFLOW} = GAS_{flow} + Diluent_{flow}$$

WHERE:

GAS_{flow} = source gas flow rate

$Diluent_{flow}$ = zero air flow rate

For instrument with multiple source gas MFC total Flow is:

Equation 1-2b

$$\boldsymbol{TOTALFLOW} = GAS_{flow\ MFC1} + GAS_{flow\ MFC2} + Diluent_{flow\ rate}$$

This dilution process is dynamic. The M700E's CPU not only keeps track of the temperature and pressure of the various gases, but also receives data on actual flow rates of the various MFC's in real time so the flow rate control can be constantly adjusted to maintain a stable output concentration.
The M700E calibrator's level of control is so precise that bottles of mixed gases can be used as source gas. Once the exact concentrations of all of the gases in the bottle are programmed into the M700E, it will create an exact output concentration of any of the gases in the bottle.

1.1.1. GAS PHASE TITRATION MIXTURES FOR O_3 AND NO_2

Because ozone is a very reactive and therefore under normal ambient conditions a short-lived gas, it can not be reliably bottled, however, an optional O_3 generator can be included in the M700E calibrator that allows the instrument to be use to create calibration mixtures that include O_3.
This ability to generate O_3 internally also allows the M700E Dynamic Dilution Calibrator to be used to create calibration mixture containing NO_2 using a gas phase titration process (GPT) by precisely mixing bottled NO of a known concentration with O_3 of a known concentration and diluent gas (zero air).
The principle of GPT is based on the rapid gas phase reaction between NO and O_3 which produces quantities of NO_2 as according to the following equation:

Equation 1-3

$$NO + O_3 \quad \rightarrow NO_2 + O_2 + hv_{(light)}$$

Under controlled circumstances the NO-O_3 reaction is very efficient (<1% residual O_3), therefore the concentration of NO_2 resulting from the mixing of NO & O_3 can be accurately predicted and controlled as long as the following conditions are met,:

a) The amount of O_3 used in the mixture is known.

b) The amount of NO used in the mixture is **AT LEAST** 10% greater than the amount O_3 in the mixture.

c) The volume of the mixing chamber is known.

d) The NO and O_3 flow rates (from which the time the two gases are in the mixing chamber) are low enough to give a residence time of the reactants in the mixing chamber of >2.75 ppm min.

Given the above conditions, the amount of NO_2 being output by the M700E will be equal to (at a 1:1 ratio) to the amount of O_3 added.
Since:

- The O_3 flow rate of the M700E's O_3 generator is a fixed value (typically about 0.105 LPM);
- The GPT chamber's volume is known,
- The source concentration of NO is a fixed value,

Once the **TOTALFLOW** is determined and entered into the M700E's memory and target concentration for the O_3 generator are entered into the calibrator's software, the M700E adjusts the NO flow rate and diluent (zero air) flow rate to precisely create the appropriate NO_2 concentration at the output.
In this case ***Totalflow*** is calculated as:

Equation 1-4a

$$TotalFlow = Dil_{Flow} - NO\ GAS - O_{3\ flow}$$

WHERE:

$NOGAS_{flow}$ = NO source gas flow rate (For calibrator's with multiple source gas MFC, $NOGAS_{flow}$ is the sum of the flow rate for all of the active cal gas MFC's)

Totalflow = total gas flow requirements of the system.

$O_{3\ flow}$ = the flow rate set for the O_3 generator.

DIL_{flow} = required diluent gas flow

Again, this is a dynamic process. An optional photometer can be added to the M700E calibrator that allows the CPU to track the ozone concentration when ozone is being produced. This information, along with the other data (gas temperature & pressure, actual flow rates, etc.) is used by the CPU to establish a very accurate NO_2 calibration mixture.

1.2. PNEUMATIC OPERATION

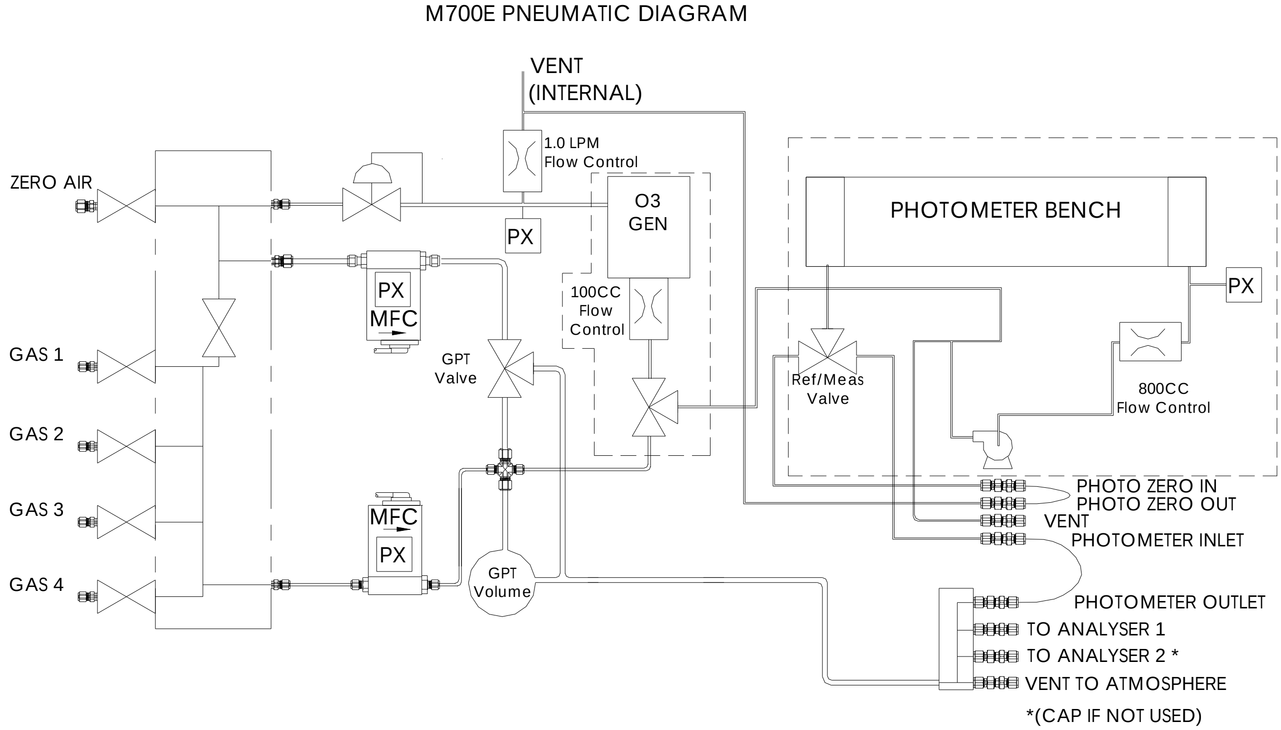


FIGURE 1-1

The M700Ecalibrator pneumatic system consists of the precision dilution system and valve manifold consisting of four gas port valves and one diluent air valve. When bottles of source gas containing different gases are connected to the four source gas inlet ports, these valves are used to select the gas type to be used by opening and closing off gas flow from the various bottles upstream of the MFC's.

NOTE: Each valve is rated for up to 40 PSI zero air pressure and the source gas pressure should be between 25 to 30 PSI and never more than 35 PSI. Exceeding 35 psi may cause leakage that could cause unwanted gases to be included in the calibration mixture.

By closing all of the four source gas input valves so that only zero air is allowed into the calibrator, the entire pneumatic system can be purges with zero air without having to manipulate the MFC's.
For instrument in which the O_3 generator and GPT pneumatics are installed a glass volume, carefully selected per the U.S.E.P.A. guidelines is used to optimize NO_2 creation.
See Figure 1-1 for descriptions of the internal pneumatics for the M700E calibrator.

1.2.1. GAS FLOW CONTROL

The precision of gas flow through the M700E Dynamic Dilution Calibrator, is centrally critical to its ability to accurately mix calibration gases. This control is established in several ways.

1.2.1.1. DILUENT AND SOURCE GAS FLOW CONTROL

Diluent and source gas flow in the M700E calibrator is directly and dynamically controlled by using highly accurate Mass Flow Controller. The MFC ‘s consist of a shunt, a sensor, a solenoid valve and the electronic circuitry required to operate them.
The shunt divides the gas flow such that the flow through the sensor is a precise percentage of the flow through the valve. The flow through the sensor is always laminar.

The MFC’s internal sensor operates on a unique thermal-electric principle. A metallic capillary tube is heated uniformly by a resistance winding attached to the midpoint of the capillary. Thermocouples are welded at equal distances from the midpoint of the tube. At zero air flow the temperature of both thermocouples will be the same. When flow occurs through the tubing, heat is transferred from the tube to the gas on the inlet side, and from the gas back to the tube on the outlet side creating an asymmetrical temperature distribution. The thermocouples sense this decrease and increase of temperature in the capillary tube and produce a mVDC output signal proportional to that change that is proportional to the rate of flow through the MFC’s valve.

The electronic circuitry reads the signal output by the thermal flow sensor measured through the capillary tube. This signal is amplified so that it is varies between 0.00 VDC and 5.00 VDC. A separate 0 to 5 VDC command voltage is also generated that is proportional to the target flow rate requested by the M700E’s CPU. The 0-5VDC command signal is electronically subtracted from the 0-5VDC flow signal The amount and direction of the movement is dependent upon the value and the sign of the differential signal.
The MFC’s valve is an automatic metering solenoid type; its height off the seat is controlled by the voltage in its coil. The controllers circuitry amplifies the differential signal obtained by comparing the control voltage to the flow sensor output and uses it to drive the solenoid valve.

The entire control loop is set up so that as the solenoid valve opens and closes to vary the flow of gas through the shunt, valve and sensor in an attempt to minimize the differential between the control voltage for the target flow rate and the and the flow sensor output voltage generated by the actual flow rate of gas through the controller.
This process is heavily dependant on the capacity of the gas to heat and cool. Since the heat capacity of many gases is relatively constant over wide ranges of temperature and pressure, the flowmeter is calibrated directly in molar mass units for known gases. Changes in gas composition usually only require application of a simple multiplier to the air calibration to account for the difference in heat capacity and thus the flowmeter is capable of measuring a wide variety of gases.

1.2.1.2. FLOW CONTROL ASSEMBLIES FOR OPTIONAL O_3 COMPONENTS

Whereas the gas flow rates for the final mixing of gases are controlled directly by the calibrator's MFC, under direction of the CPU, gas flow through the ozone components is controlled by various flow control assemblies located in the gas stream(s). These orifices are not adjusted but maintain precise volumetric control as long as the critical pressure ratio is maintained between the upstream and the downstream orifice.

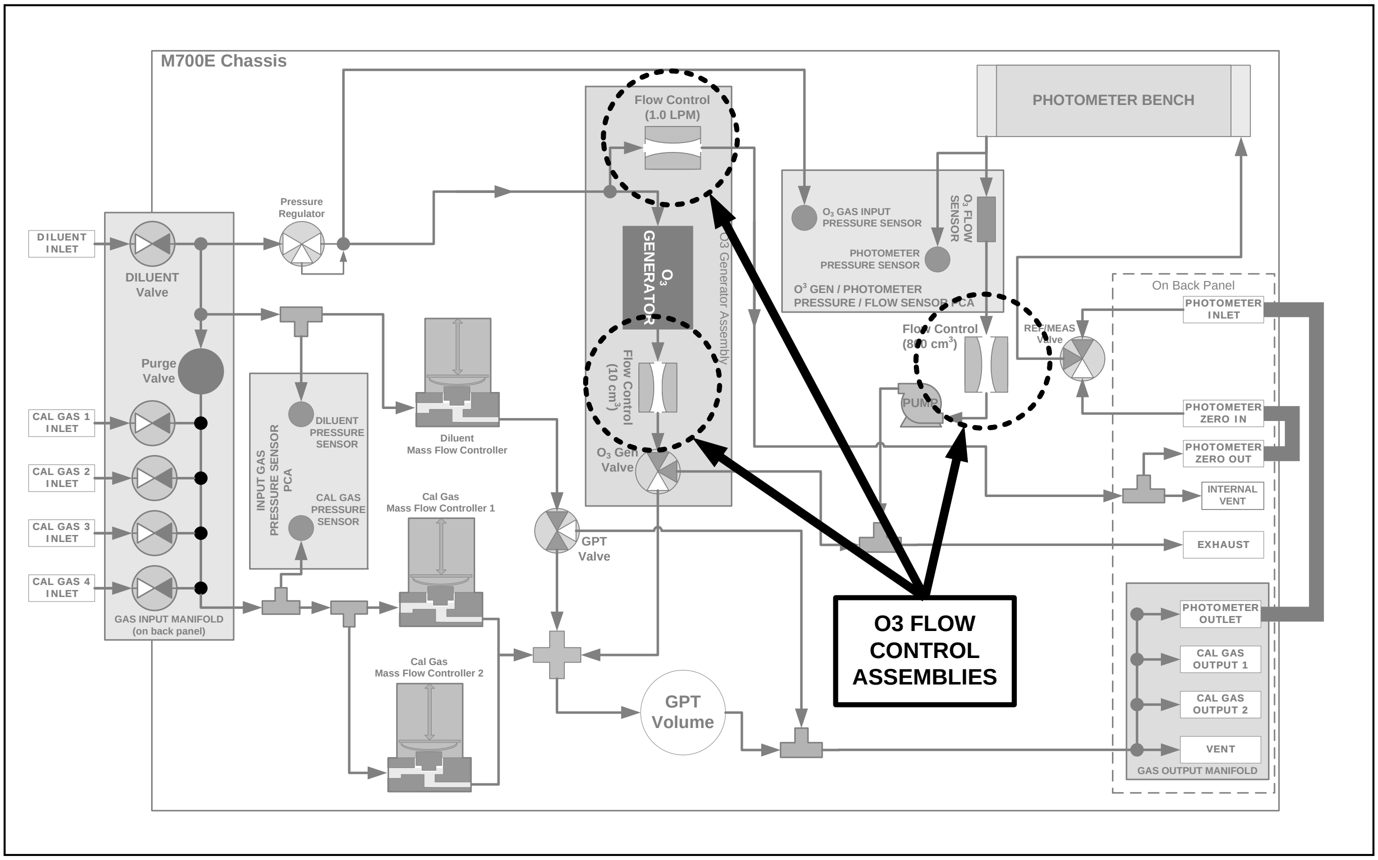


Figure 1-1a: Location of Gas Flow Control Assemblies for M700E's with O_3 options Installed

1.2.1.3. CRITICAL FLOW ORIFICES

The most important component of the flow control assembly is the critical flow orifice.
Critical flow orifices are a remarkably simple way to regulate stable gas flow rates. They operate without moving parts by taking advantage of the laws of fluid dynamics. By restricting the flow of gas though the orifice, a pressure differential is created. This pressure differential combined with the action of the calibrator's pump draws the gas through the orifice.

As the pressure on the downstream side of the orifice (the pump side) continues to drop, the speed that the gas flows though the orifice continues to rise. Once the ratio of upstream pressure to downstream pressure is greater than 2:1, the velocity of the gas through the orifice reaches the speed of sound. As long as that ratio stays at least 2:1 the gas flow rate is unaffected by any fluctuations, surges, or changes in downstream pressure because such variations only travel at the speed of sound themselves and are therefore cancelled out by the sonic shockwave at the downstream exit of the critical flow orifice.

The flow orifice assemblies consist of:

- A critical flow orifice.
- Two o-rings: Located just before and after the critical flow orifice, the o-rings seal the gap between the walls of assembly housing and the critical flow orifice.
- A spring: Applies mechanical force needed to form the seal between the o-rings, the critical flow orifice and the assembly housing.
- A sintered filter: Located just after the spring, a 20 micron stainless steel filter used to remove any debris that may have entered the pneumatic path.

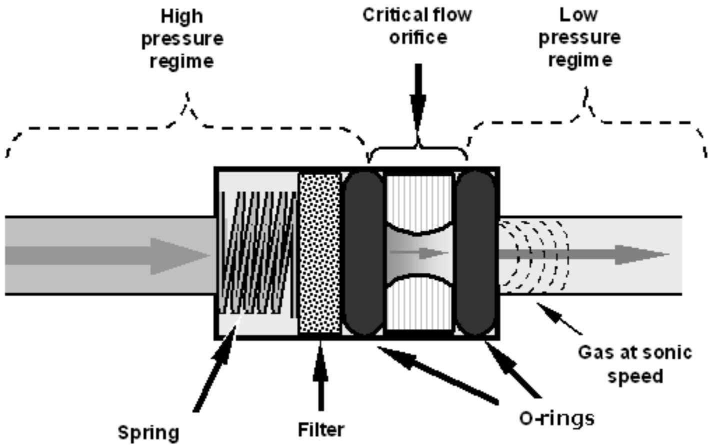


Figure 1-2: Flow Control Assembly & Critical Flow Orifice

1.2.1.4. CRITICAL FLOW ORIFICES

The actual flow rate of gas through the orifice (volume of gas per unit of time), depends on the size and shape of the aperture in the orifice. The larger the diameter of the hole, the more gas molecules moving at the speed of sound passes through the orifice. Respectively the ratio of the pressure upstream and downstream of the critical flow orifice is largely exceeded and accommodates a wide range of possible variability in atmospheric pressure and pump degradation extending the useful life of the pump. Instruments located at altitude have the ambient pressure much lower than at sea level (1”HG for every 1000’), the 2:1 ratio can be approached at high altitudes as the pump degrades in its ability to apply vacuum.

1.2.2. INTERNAL GAS PRESSURE SENSORS

Depending upon how many and which options are installed in the M700E calibrator, there are between two and four pressure sensors installed as well as a pressure regulator.
In the basic unit a printed circuit assembly located near the front of the calibrator near the MFC’s includes sensors that measure the pressure of the diluent gas and the source gas currently selected to flow into the calibrator. The calibrator monitors these sensors.

- Should the pressure of one of them fall below 15 PSIG or rise above 33 PSIG a warning is issued.

In units with the optional O_3 generator installed a second PCA located at the rear of the calibrator just behind the generator assembly includes a sensor that measures the gas pressure of the zero air flowing into the generator. A regulator is also located on the gas input to the O_3 generator that maintains the pressure differential needed for the critical flow orifice to operate correctly.

- Should the pressure of one of this sensor fall below 15 PSIG or rise above 25 PSIG a warning is issued.

In calibrators with an O_3 photometer installed, a second pressure located on the rear PCA measures the pressure of gas in the photometer's absorption tube. This data is used by the CPU when calculating the O_3 concentration inside the absorption tube.

1.3. ELECTRONIC OPERATION

1.3.1. OVERVIEW

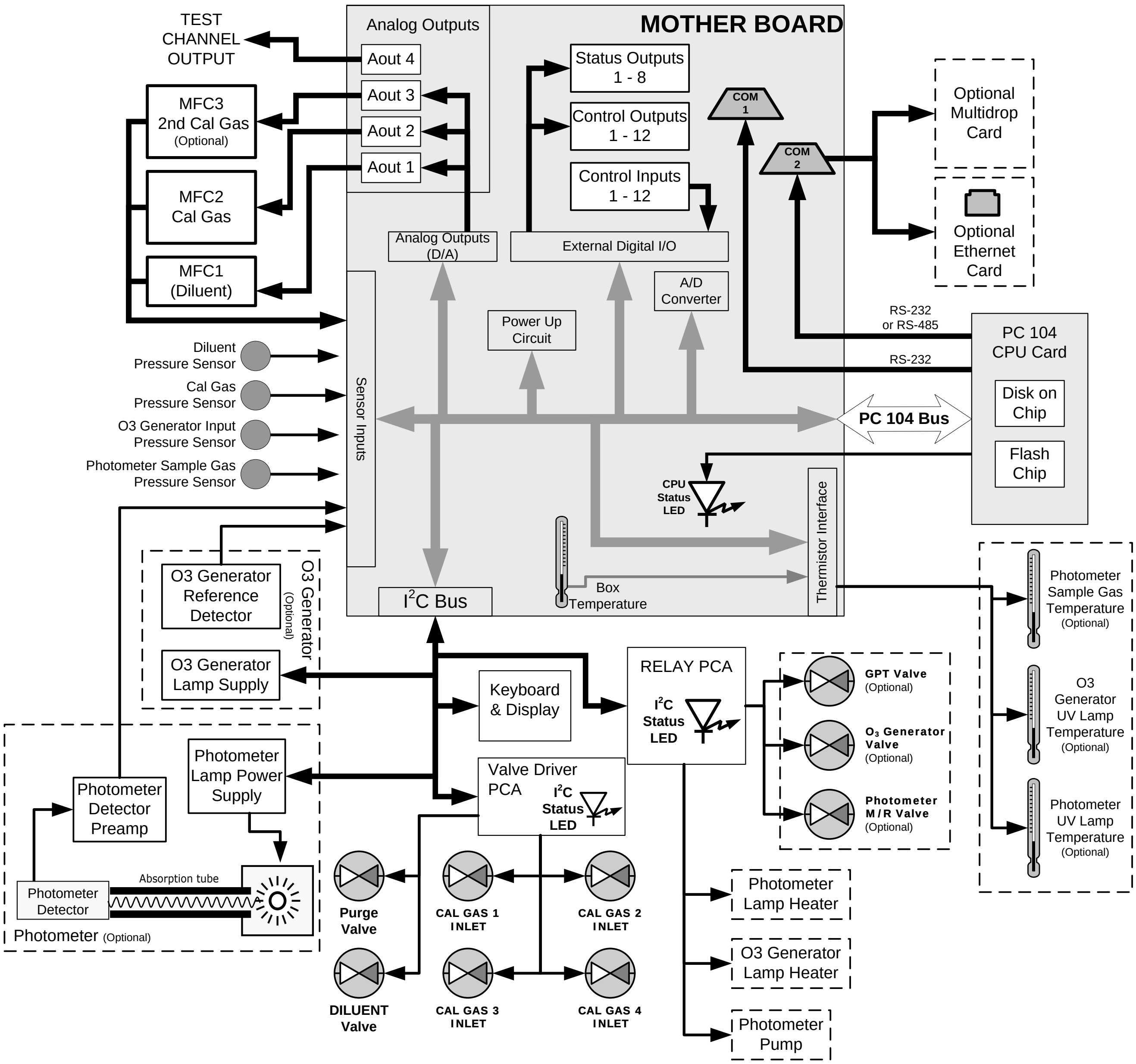


Figure 1-3: M700E Electronic Block Diagram

At its heart the calibrator is a microcomputer (CPU) that controls various internal processes, interprets data, makes calculations, and reports results using specialized firmware developed by Teledyne API. It communicates with the user as well as receives data from and issues commands to a variety of peripheral devices via a separate printed circuit assembly called the Motherboard.

The motherboard collects data, performs signal conditioning duties and routes incoming and outgoing signals between the CPU and the calibrator's other major components.

Data is generated by the various sub components of the M700E (e.g. flow data from the MFC's, O_3 concentration from the optional photometer). Analog signals are converted into digital data by a uni-polar, analog-to-digital converter, located on the mother board.

A variety of sensors report the physical and operational status of the calibrator's major components, again through the signal processing capabilities of the motherboard. These status reports are used as data for the concentration calculations and as trigger events for certain control commands issued by the CPU. They are stored in memory by the CPU and in most cases can be viewed but the user via the front panel display.
The CPU communicates with the user and the outside world in a variety of manners:

- Through the calibrator's keyboard and vacuum florescent display over a clocked, digital, serial I/O bus (using a protocol called I^2C)
- RS232 & RS485 serial I/O channel
- Via an optional Ethernet communications card
- Various digital and analog outputs, and
- A set of digital control input channels

Finally, the CPU issues commands via a series of relays and switches (also over the I^2C bus) located on a separate printed circuit assembly to control the function of key electromechanical devices such as heaters, motors and valves.

1.3.2. CPU

The CPU is a low power (5 VDC, 0.8A max), high performance, 386-based microcomputer running a version of the DOS operating system. Its operation and assembly conform to the PC-104 specification, version 2.3 for embedded PC and PC/AT applications. It has 2 MB of DRAM memory on board and operates at 40 MHz clock rate over an internal, 32-bit data and address bus. Chip to chip data handling is performed by two 4-channel, direct memory access (DMA) devices over data busses of either 8-bit or 16-bit bandwidth. The CPU supports both RS-232 and RS-485 serial protocols. Figure 1- shows the CPU board.

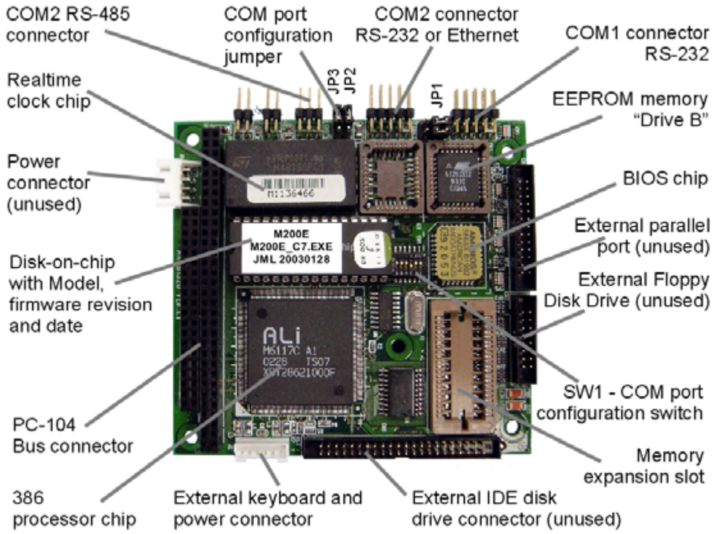


Figure 1-4: M700E CPU Board Annotated

1.3.2.1. DISK ON CHIP

Technically, the disk-on-chip (DOC) is an EEPROM, but appears to the CPU as, behaves as, and performs the same functions in the system as an 8 mb disk drive, internally labeled as DOS drive C:\. It is used to store the computer's operating system files, the Teledyne Instruments firmware and peripheral files, and the operational data generated by the calibrator's internal data acquisition system.

1.3.2.2. FLASH CHIP

The flash chip is another, smaller EEPROM with about 64 kb of space, internally labeled as DOS drive B:\. The M700E CPU board can accommodate up to two EEPROM flash chips. The M700E standard configuration is one chip with 64 kb of storage capacity, which is used to store the calibrator configuration as created during final checkout at the factory. Separating this data onto a less frequently accessed chip significantly decreases the chance of data corruption through drive failure.
In the unlikely event that the flash chip should fail, the calibrator will continue to operate with just the DOC. However, all configuration information will be lost, requiring the unit to be recalibrated.

1.3.3. RELAY PCA

The relay board is one of the central switching and power distribution units of the calibrator. It contains power relays, valve drivers and status LEDs for all heated zones and valves, as well as thermocouple amplifiers, power distribution connectors and the two switching power supplies of the calibrator. The relay board communicates with the motherboard over the I^2C bus and can be used for detailed trouble-shooting of power problems and valve or heater functionality.
Generally the relay PCA is located in the right-rear quadrant of the calibrator and is mounted vertically on the back side of the same bracket as the instrument's DC power supplies, however the exact location of the relay PCA may differ from model to model.

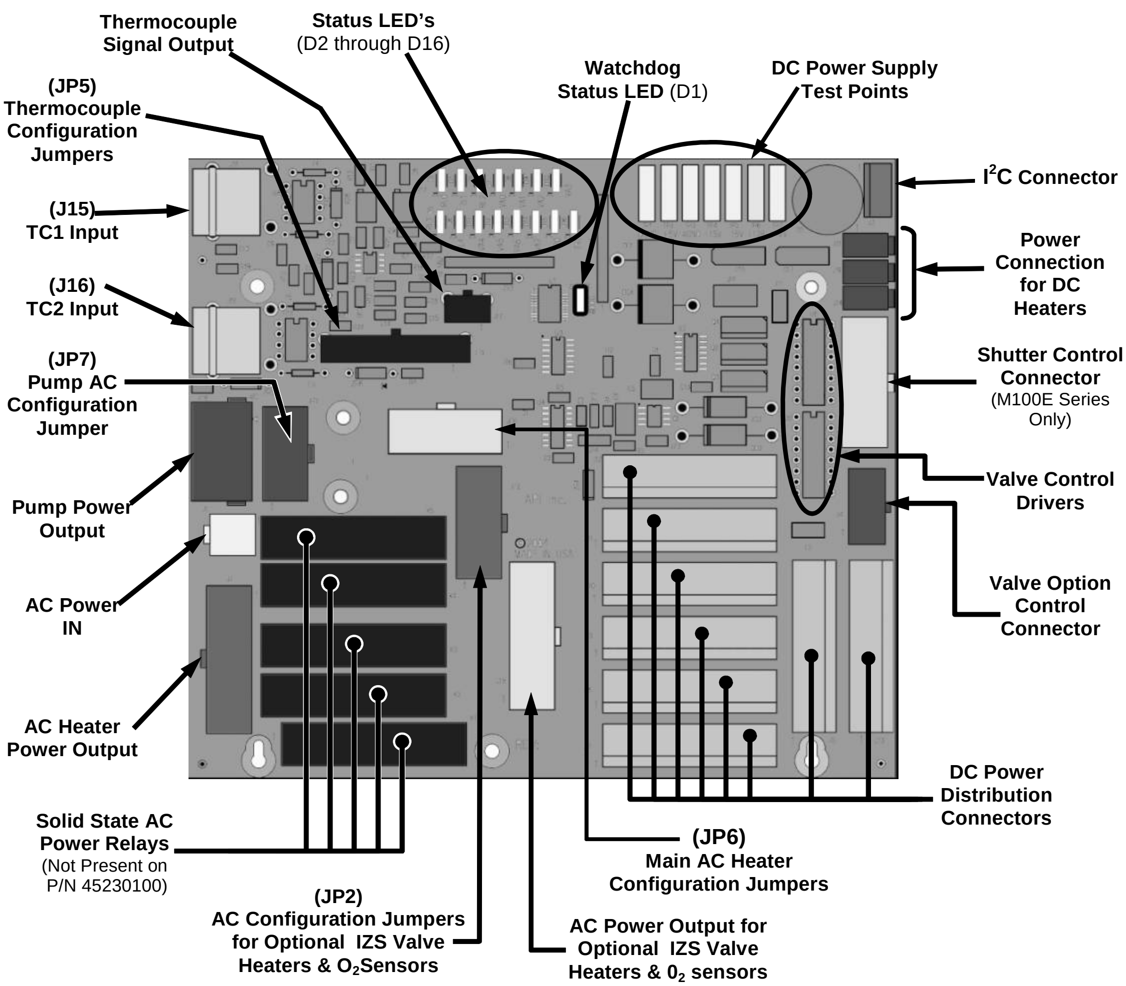


Figure 1-5: Relay Board PCA

1.3.3.1. VALVE CONTROL

The relay board also hosts two valve driver chips, each of which can drive up four valves. In the M700E the relay PCA controls only those valves associated with the O_3 generator and photometer options. All valves related to source gas and diluent gas flow are controlled by a separate valve driver PCA.

1.3.3.2. **HEATER CONTROL**

The relay PCA controls the various DC heaters related to the O_3 generator and photometer options.

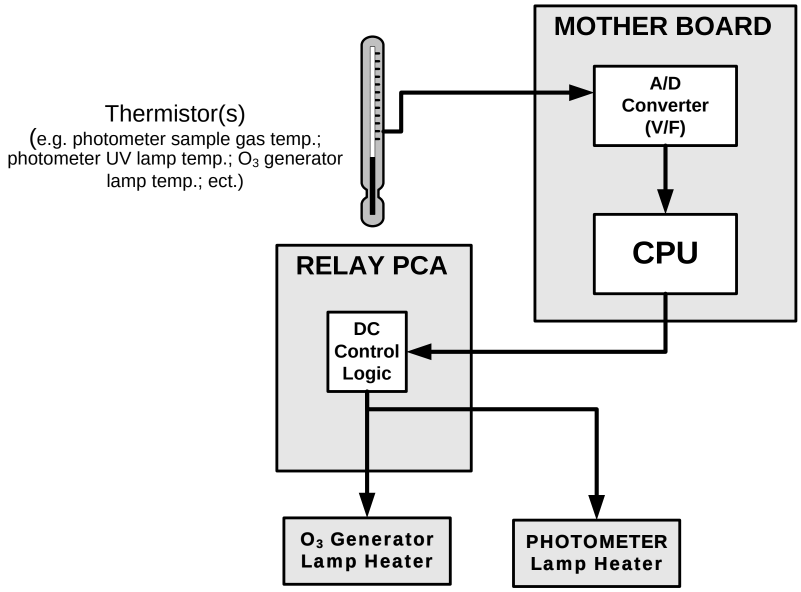


Figure 1-6: Heater Control Loop Block Diagram.

1.3.3.3. **RELAY PCA STATUS LEDS & WATCH DOG CIRCUITRY**

LEDs are located on the calibrator's relay board to indicate the status of the calibrator's heating zones and some of its valves as well as a general operating watchdog indicator. Table 1-1 shows the states of these LEDs and their respective functionality.

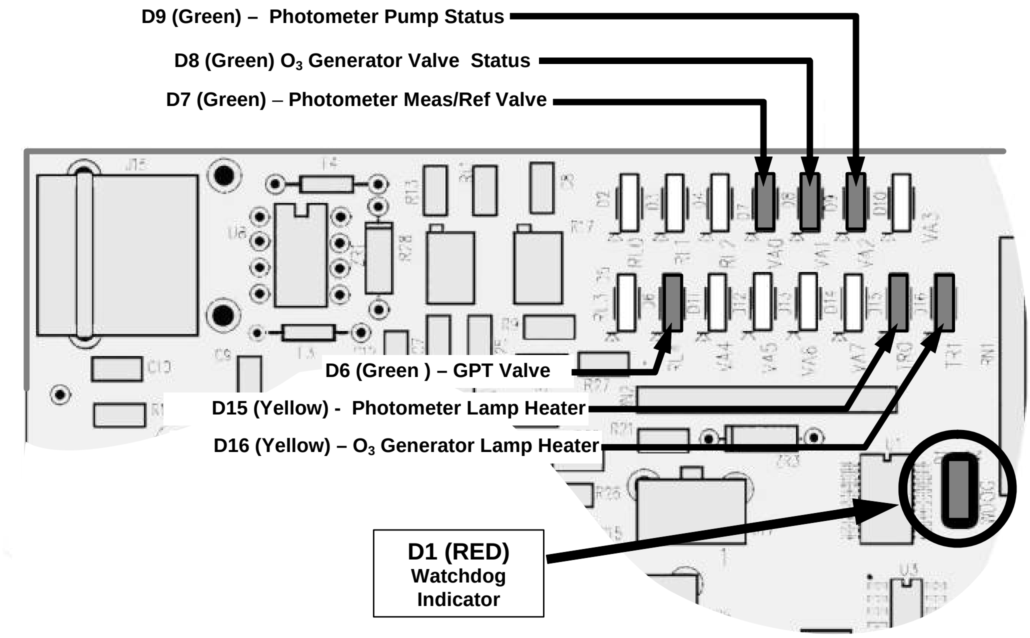


Figure 1-7: Status LED Locations – Relay PCA

Table 1-1: Relay Board Status LEDs

LED	COLOR	DESCRIPTION	FUNCTION
D1	Red	Watchdog Circuit; I^2C bus operation.	Blinks when I^2C bus is operating properly
D2-6	SPARE		
D7 [1]	Green	Valve Photometer Meas/Ref	When lit the valve open to REFERENCE gas path
D8 [1]	Green	O_3 generator valve status	When lit the valve open to O_3 generator gas path
D9	Green	Photometer pump	When lit the pump is turner on.
D6	Yellow	GPT valve status	When lit the valve is open to GPT Chamber
D10 - 14	SPARE		
D15	Yellow	Photometer Heater Status	When lit the photometer UV lamp heater is on
D16	Yellow	Relay 4 – (O_2 sensor heater 200EH/EM)	When lit the O_3 generator UV lamp heater is on

1.3.3.4. **RELAY PCA WATCHDOG INDICATOR (D1)**

The most important status LED on the relay board is the red I^2C Bus watch-dog LED. It is controlled directly by the calibrator's CPU over the I^2C bus. Special circuitry on the relay PCA watches the status of D1. Should this LED ever stay ON or OFF for 30 seconds, indicating that the CPU or I^2C bus has stopped functioning, this watchdog circuit automatically shuts off all valves and turns off all heaters and lamps.

1.3.4. VALVE DRIVER PCA

The valves that operate the M700E calibrator's main source gas and diluent gas inputs are controlled by a printed circuit assembly that is attached directly to the input valve manifold. Like the relay PCA, the valve driver PCA communicates with M700E's CPU through the motherboard over the I^2C bus.

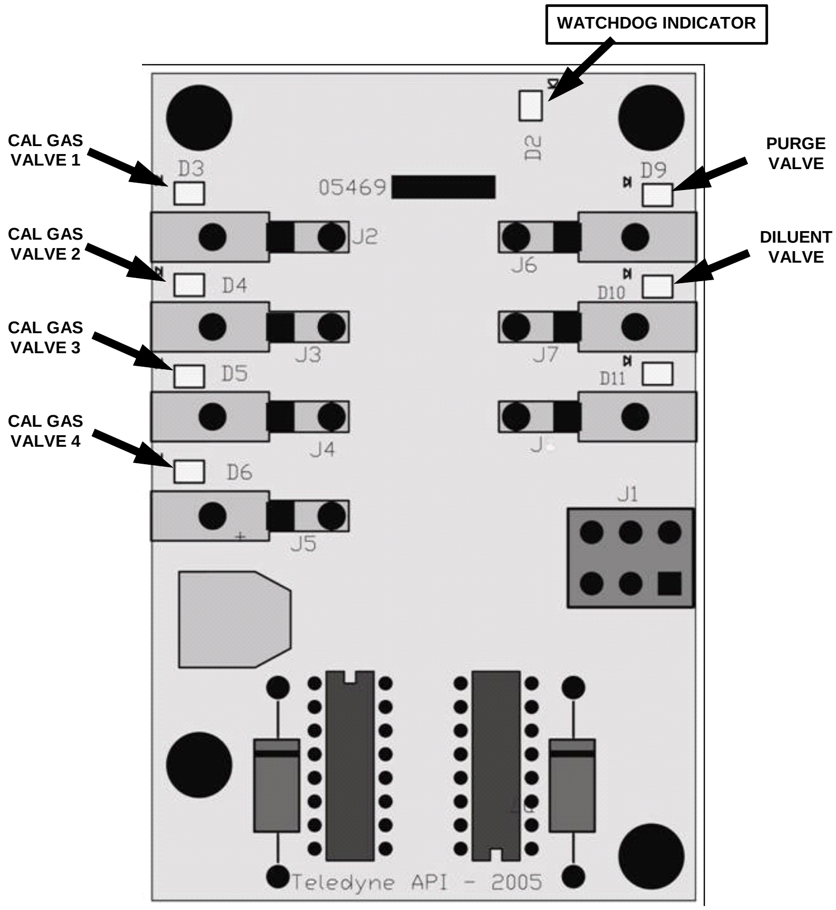


Figure 1-8: Status LED Locations – Valve Driver PCA

1.3.5. MOTHERBOARD

This is the largest electronic assembly in the calibrator and is mounted to the rear panel as the base for the CPU board and all I/O connectors. This printed circuit assembly provides a multitude of functions including A/D conversion, digital input/output, PC-104 to I^2C translation, temperature sensor signal processing and is a pass through for the RS-232 and RS-485 signals.

1.3.5.1. A TO D CONVERSION

Analog signals, such as the voltages received from the calibrator's various sensors, are converted into digital signals that the CPU can understand and manipulate by the analog to digital converter (A/D). Under the control of the CPU, this functional block selects a particular signal input and then coverts the selected voltage into a digital word.

The A/D consists of a voltage-to-frequency (V-F) converter, a programmable logic device (PLD), three multiplexers, several amplifiers and some other associated devices. The V-F converter produces a frequency proportional to its input voltage. The PLD counts the output of the V-F during a specified time period, and sends the result of that count, in the form of a binary number, to the CPU.

The A/D can be configured for several different input modes and ranges but in the is used in uni-polar mode with a +5V full scale. The converter includes a 1% over and under-range. This allows signals from -0.05V to +5.05V to be fully converted.

For calibration purposes, two reference voltages are supplied to the A/D converter: Reference ground and Reference voltage +4.096 VDC. During calibration, the device measures these two voltages, outputs their digital equivalent to the CPU. The CPU uses these values to compute the converter's offset and slope and uses these factors for subsequent conversions.

1.3.5.2. SENSOR INPUTS

The key analog sensor signals are coupled to the A/D converter through the master multiplexer from two connectors on the motherboard. Terminating resistors (100 kΩ) on each of the inputs prevent cross-talk between the sensor signals.

1.3.5.3. THERMISTOR INTERFACE

This circuit provides excitation, termination and signal selection for several negative-coefficient, thermistor temperature sensors located inside the calibrator. They are:

1.3.5.4. ANALOG OUTPUTS

The M700E calibrator comes equipped with one analog output. It can be set by the user to carry the current signal level of any one of the parameters and will output an analog VDC signal that rises and falls in relationship with the value of the parameter.

1.3.5.5. EXTERNAL DIGITAL I/O

The external digital I/O performs two functions.
The STATUS outputs carry logic-level (5V) signals through an optically isolated 8-pin connector on the rear panel of the calibrator. These outputs convey on/off information about certain calibrator conditions such as **SYSTEM OK**. They can be used to interface with certain types of programmable devices.
The CONTROL inputs can be initiated by applying 5V DC power from an external source such as a PLC or data logger. Zero and span calibrations can be initiated by contact closures on the rear panel.

1.3.5.6. I^2C DATA BUS

I^2C is a two-wire, clocked, digital serial I/O bus that is used widely in commercial and consumer electronic systems. A transceiver on the motherboard converts data and control signals from the PC-104 bus to I^2C. The data are then fed to the keyboard/display interface and finally onto the relay board.
Interface circuits on the keyboard/display interface and relay board convert the I^2C data to parallel inputs and outputs. An additional interrupt line from the keyboard to the motherboard allows the CPU to recognize and service key strokes on the keyboard.

1.3.5.7. POWER-UP CIRCUIT

This circuit monitors the +5V power supply during calibrator start-up and sets the analog outputs, external digital I/O ports, and I^2C circuitry to specific values until the CPU boots and the instrument software can establish control.

1.3.6. POWER SUPPLY AND CIRCUIT BREAKER

The M700E calibrator operates in two main AC power ranges: 100-120 VAC and 220-240 VAC (both ± 10%) between 47 and 63 Hz. A 5 ampere circuit breaker is built into the ON/OFF switch. In case of a wiring fault, the circuit breaker will automatically turn off the calibrator.

NOTE:

The M700E calibrator is equipped with a universal power supply that allows it to accept any AC power configuration, within the limits specified in Table 7-2.

CAUTION
Should the power circuit breaker trip, correct the condition causing this situation before turning the calibrator back on.

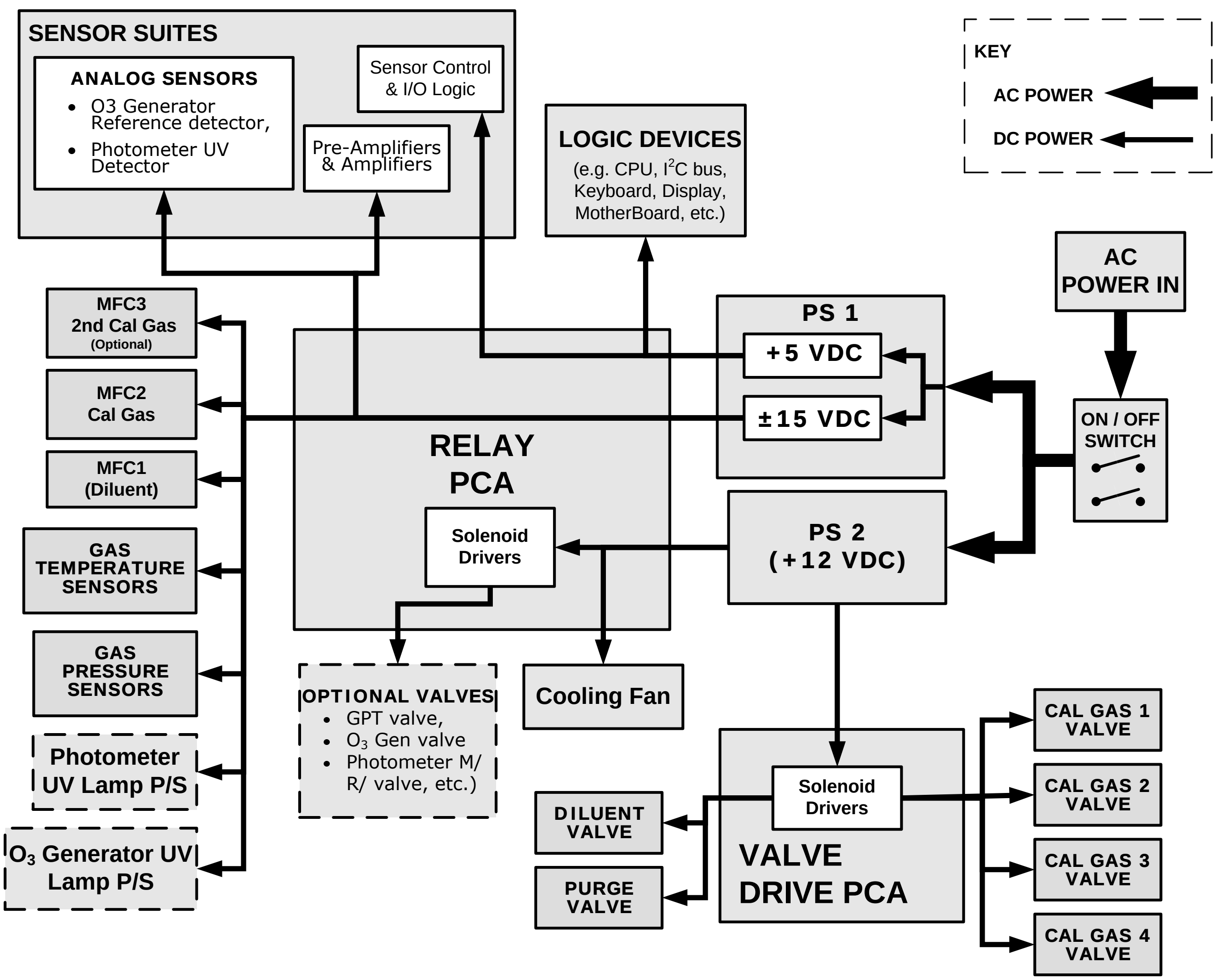


Figure 1-9: M700E Power Distribution Block diagram

1.4. FRONT PANEL INTERFACE

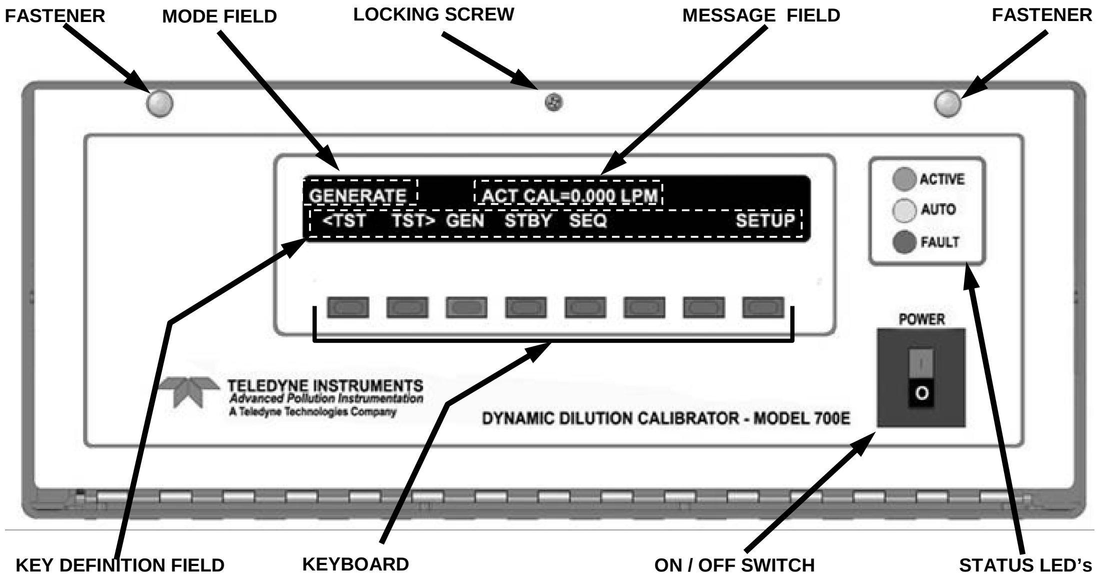


Figure 1-10: M700E Front Panel Layout

The most commonly used method for communicating with the M700E Dynamic Dilution Calibrator is via the instrument's front panel which includes a set of three status LEDs, a vacuum florescent display and a keyboard with 8 context sensitive keys.

1.4.1.1. CALIBRATOR STATUS LED'S

Three LEDS are used to inform the user of the instruments basic operating status

Table 1-3: Front Panel Status LED's

Name	Color	Behavior	Significance
Main Message Field	N/A	Displays Warning messages and Test Function values	At initial start up the various warning messages will appear here (see Section 3.2.3 below).
Mode Field	N/A	Displays "STANDBY"	Instrument is in **STANDBY** mode.
STATUS LED's			
Active	Green	OFF	Unit is operating in **STANDBY** mode. This LED glows green when the instrument is actively producing calibration gas.
Auto	Yellow	OFF	This LED only glows when the calibrator is performing and automatic calibration sequence.
Fault	Red	BLINKING	The calibrator is warming up and therefore many of its subsystems are not yet operating within their optimum ranges. Various warning messages will appear.

1.4.1.2. **KEYBOARD**

A row of eight keys just below the vacuum florescent display is the main method by which the user interacts with the calibrator. As the software is operated, labels appear on the bottom row of the display directly above each active key, defining the function of that key as it is relevant for the operation being performed. Pressing a key causes the associated instruction to be performed by the calibrator.
Note that the keys do not auto-repeat. In circumstances where the same key must be activated for two consecutive operations, it must be released and re-pressed.

1.4.1.3. **DISPLAY**

The main display of the calibrator is a vacuum florescent display with two lines of 40 text characters each. Information is organized in the following manner (see Figure 1-10):

- MODE FIELD: Displays the name of the calibrator’s current operating mode.
- MESSAGE FIELD: Displays a variety of informational messages such as warning messages, operation data and response messages during interactive tasks.
- KEY DEFINITION FIELD: Displays the definitions for the row of keys just below the display. These definitions dynamic, context sensitive and software driven.

1.4.1.4. **KEYBOARD/DISPLAY INTERFACE ELECTRONICS**

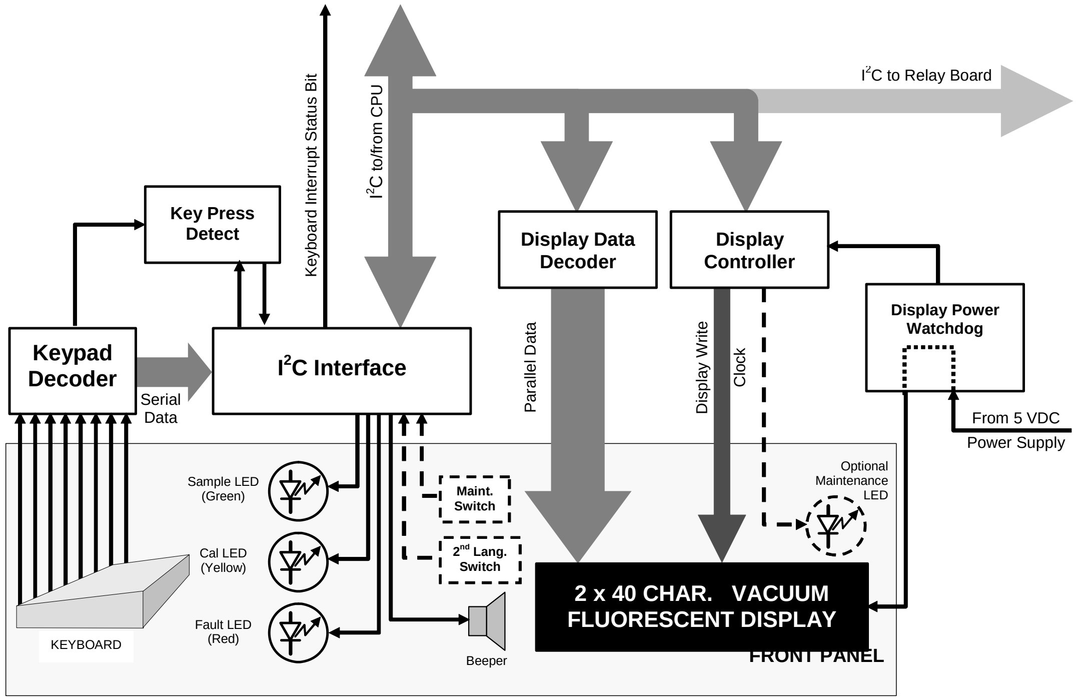


Figure 1-11: Keyboard and Display Interface Block Diagram

The keyboard/display interface electronics of the M700E Calibrator watches the status of the eight front panel keys, alerts the CPU when keys are depressed, translates data from parallel to serial and back and manages communications between the keyboard, the CPU and the front panel display. Except for the Keyboard interrupt status bit, all communication between the CPU and the keyboard/display is handle by way of the instrument's I^2C buss. The CPU controls the clock signal and determines when the various devices on the bus are allowed to talk or required to listen. Data packets are labeled with addresses that identify for which device the information is intended.

KEYPAD DECODER

Each key on the front panel communicates with a decoder IC via a separate analog line. When a key is depressed the decoder chip notices the change of state of the associated signal; latches and holds the state of all eight lines (in effect creating an 8-bit data word); alerts the key-depress-detect circuit (a flip-flop IC); translates the 8-bit word into serial data and; sends this to the I^2C interface chip.

KEY-DEPRESS-DETECT CIRCUIT

This circuit flips the state of one of the inputs to the I^2C interface chip causing it to send an interrupt signal to the CPU

I^2C INTERFACE CHIP

- This IC performs several functions:
- Using a dedicated digital status bit, it sends an interrupt signal alerting the CPU that new data from the keyboard is ready to send.
- Upon acknowledgement by the CPU that it has received the new keyboard data, the I^2C interface chip resets the key-depress-detect flip-flop.
- In response to commands from the CPU, it turns the front panel status LEDs on and off and activates the beeper.
- Informs the CPU when the optional maintenance and second language switches have been opened or closed.

DISPLAY DATA DECODER

This decoder translates the serial data sent by the CPU (in TTY format) into a bitmapped image which is sent over a parallel data bus to the display.

DISPLAY CONTROLLER

This circuit manages the interactions between the display data decoder and the display itself. It generates a clock pulse that keeps the two devices synchronized. It can also, in response to commands from the CPU turn off and/or reset the display.

DISPLAY POWER WATCHDOG

The M700E calibrator's display can begin to show garbled information or lock-up if the DC voltage supplied to it falls too low, even momentarily. To alleviate this, a brown-out watchdog circuit monitors the level of the power supply and in the event that the voltage level falls below a certain level resets the display by turning it off, then back on.

1.5. SOFTWARE ORPERATION

The M700E calibrator's core module is a high performance, 386-based microcomputer running a version of DOS. On top of the DOS shell, special software developed by Teledyne Instruments interprets user commands from various interfaces, performs procedures and tasks, stores data in the CPU's memory devices and calculates the concentrations of NO_X in the sample gas. Figure 1-12 shows a block diagram of this software functionality.

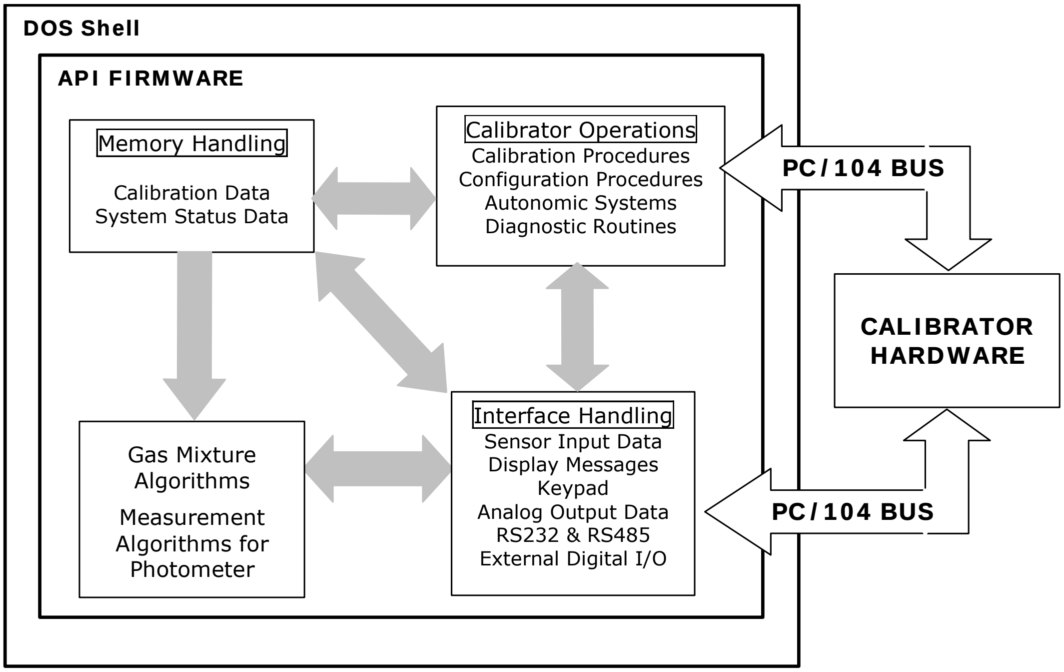


Figure 1-12: Schematic of Basic Software Operation

2. PNEUMATIC DIAGRAM

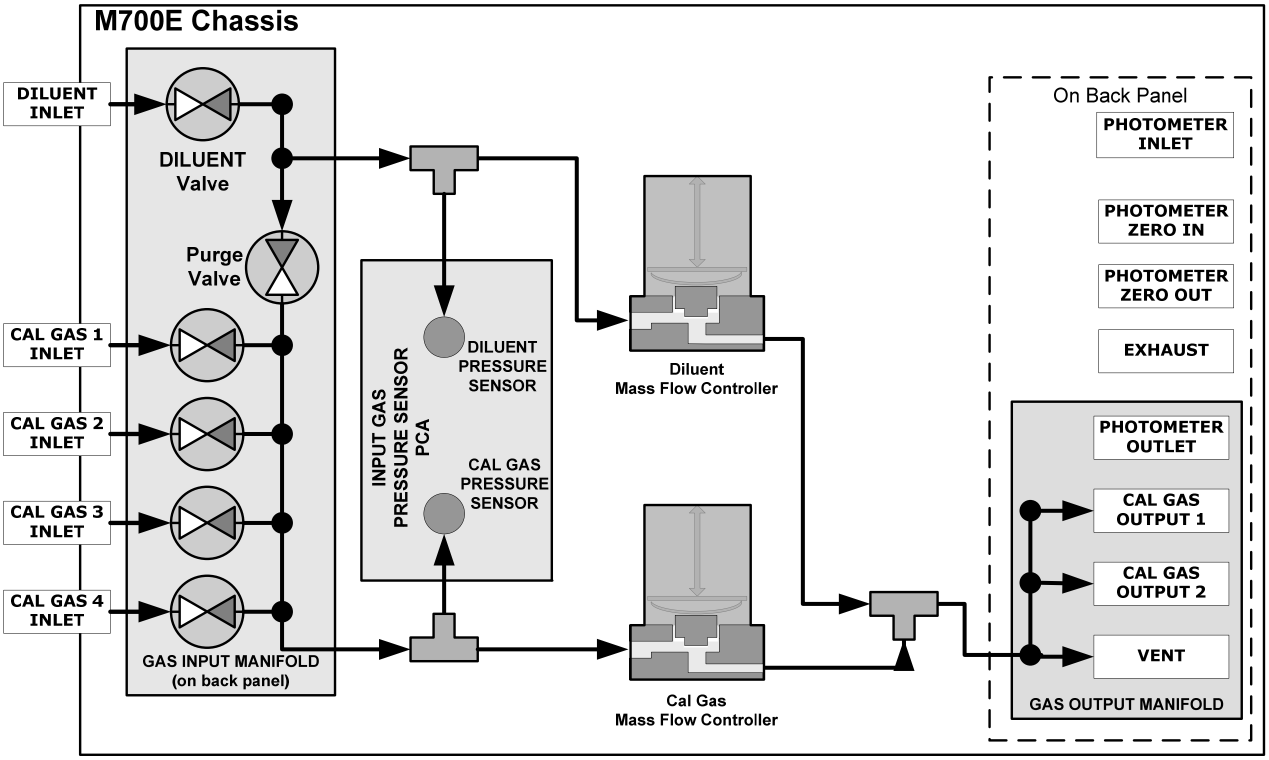


Figure 2-1: M700E Pneumatic Diagram – Base Unit

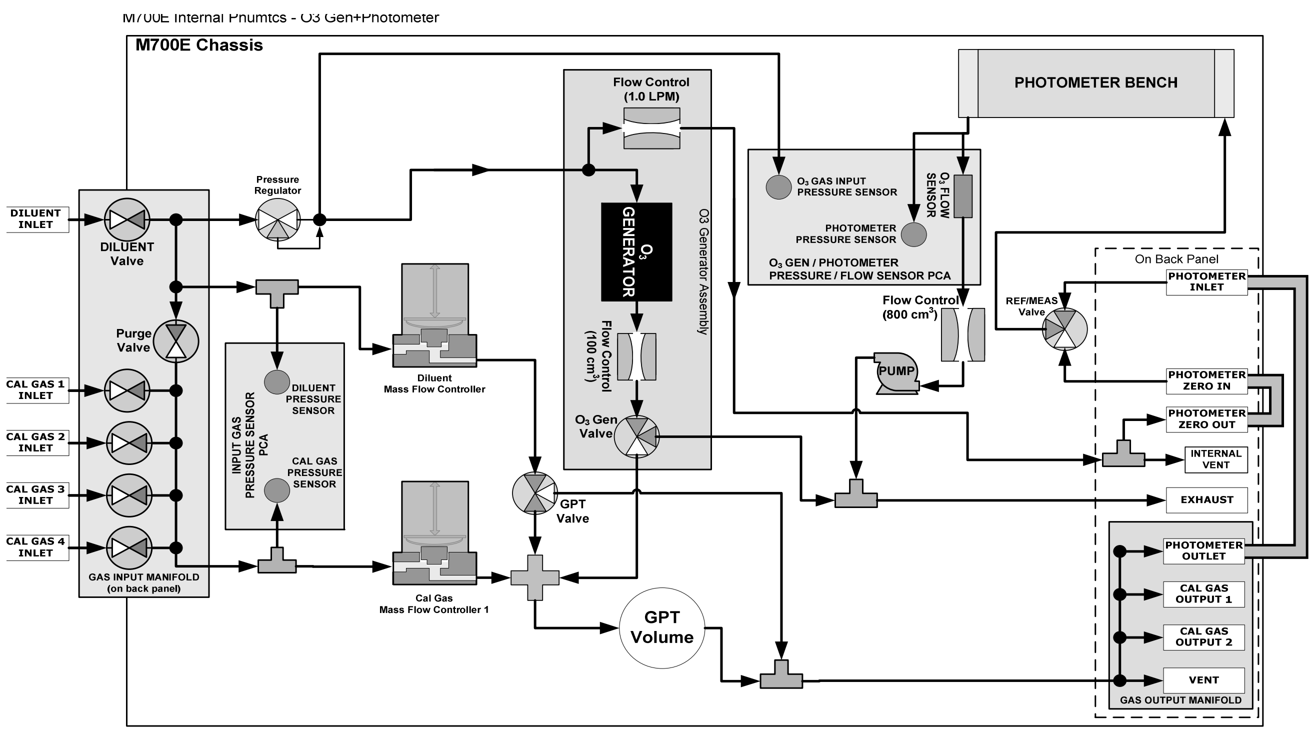
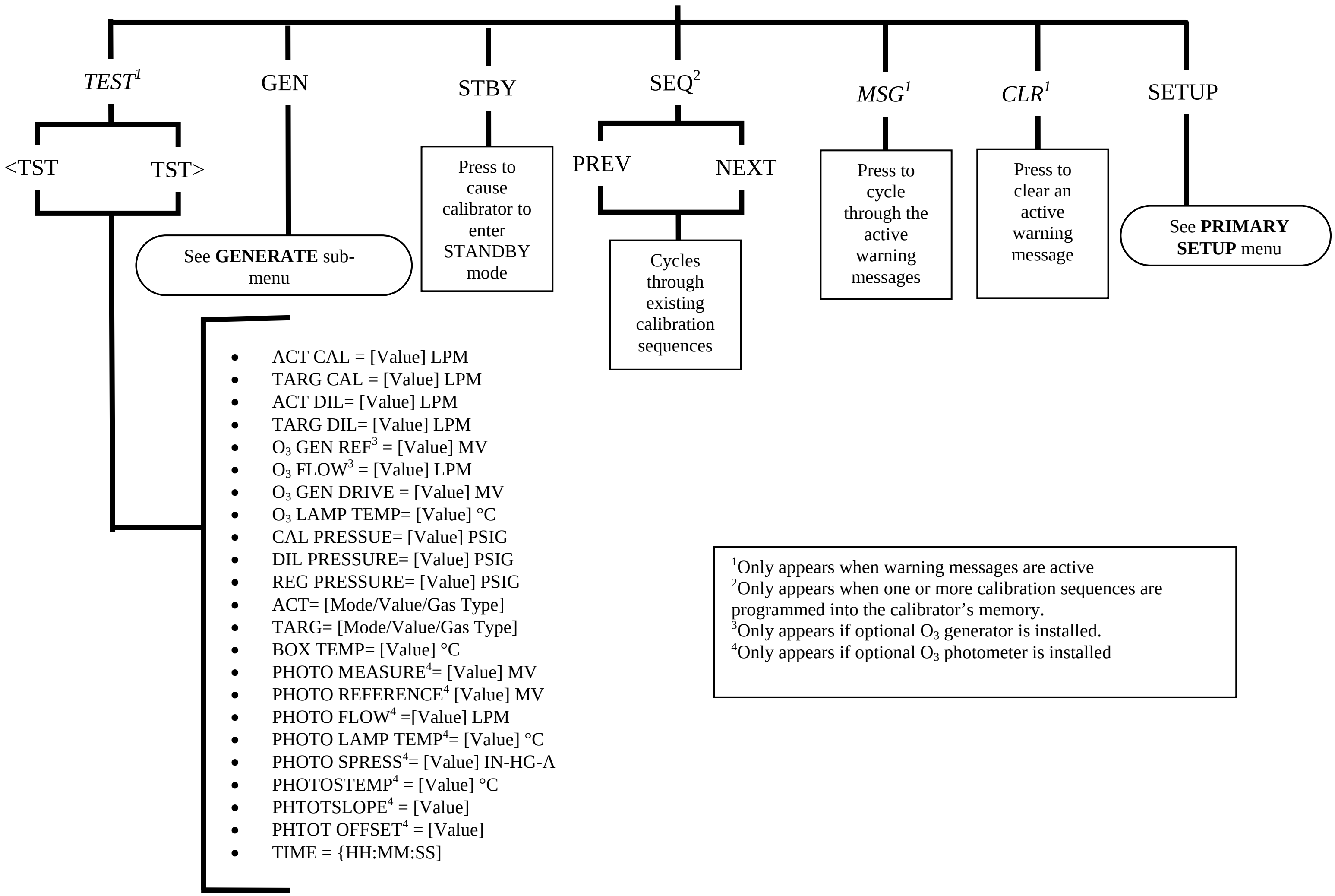


Figure 2-2: M700E Pneumatic Diagram – with O_3 Generator and Photometer

3. MENU STRUCTURE

APPENDIX A-1: M700E Dynamic Dilution Calibrator Software Menu Trees, Revision B1



[1]Only appears when warning messages are active
[2]Only appears when one or more calibration sequences are programmed into the calibrator's memory.
[3]Only appears if optional O_3 generator is installed.
[4]Only appears if optional O_3 photometer is installed

Figure A-1: Main Menu

Figure A-2: MAIN Menu - GENERATE Submenu

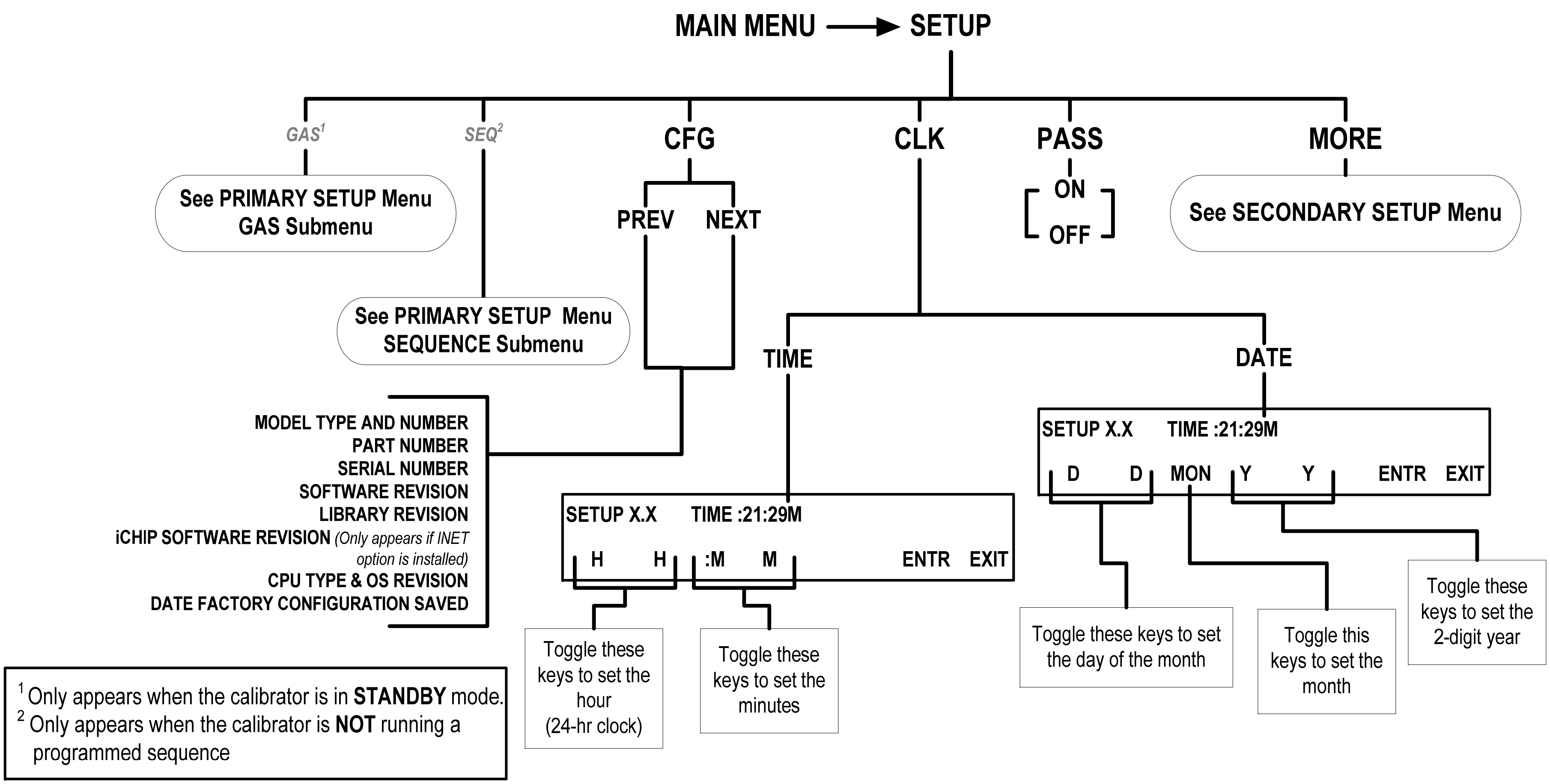
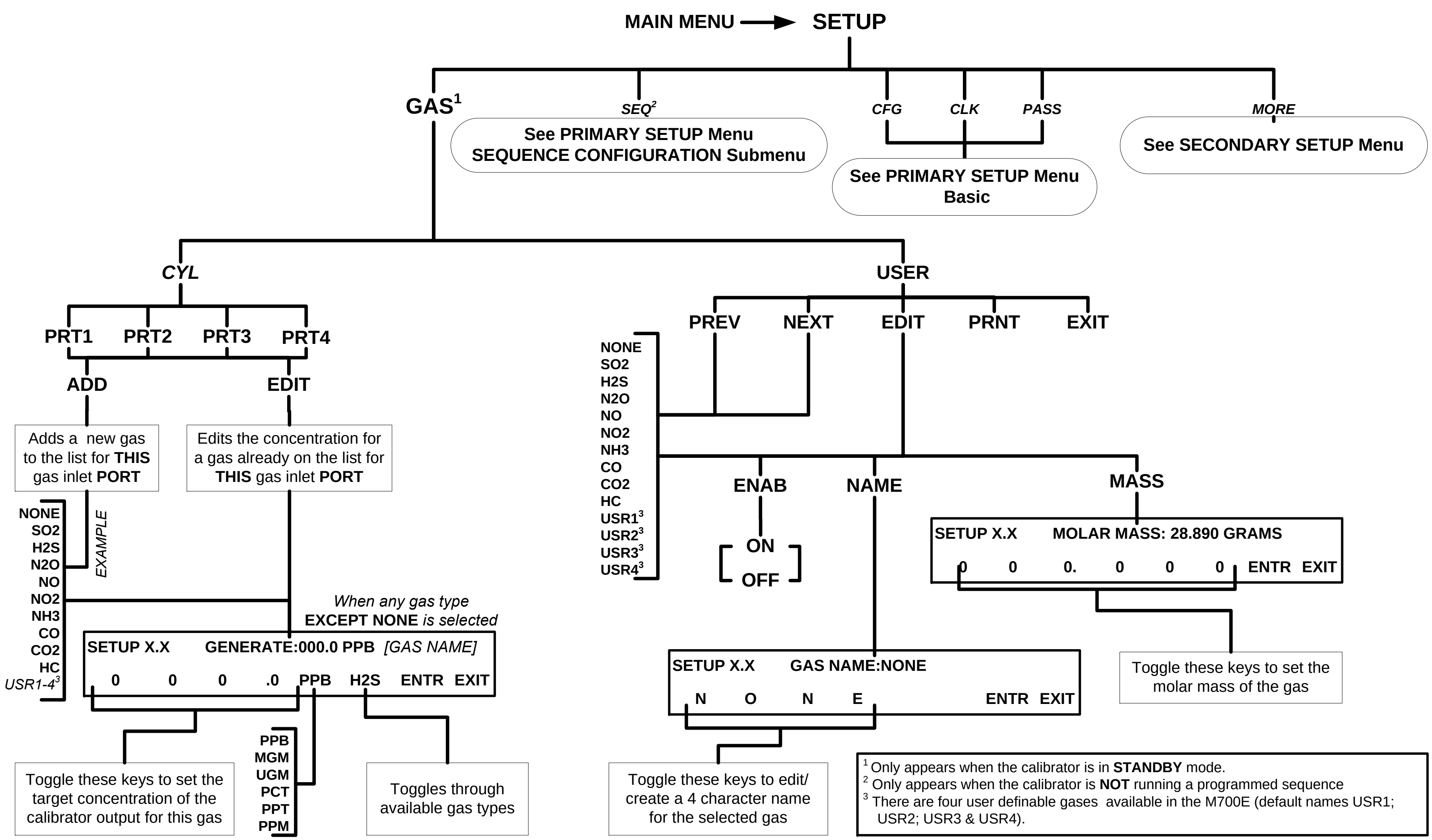


Figure A-3: PRIMARY SETUP MENU - Basics



[1] Only appears when the calibrator is in **STANDBY** mode.
[2] Only appears when the calibrator is **NOT** running a programmed sequence
[3] There are four user definable gases available in the M700E (default names USR1; USR2; USR3 & USR4).

Figure A-4: PRIMARY SETUP Menu - SOURCE GAS CONFIGURATION Submenu

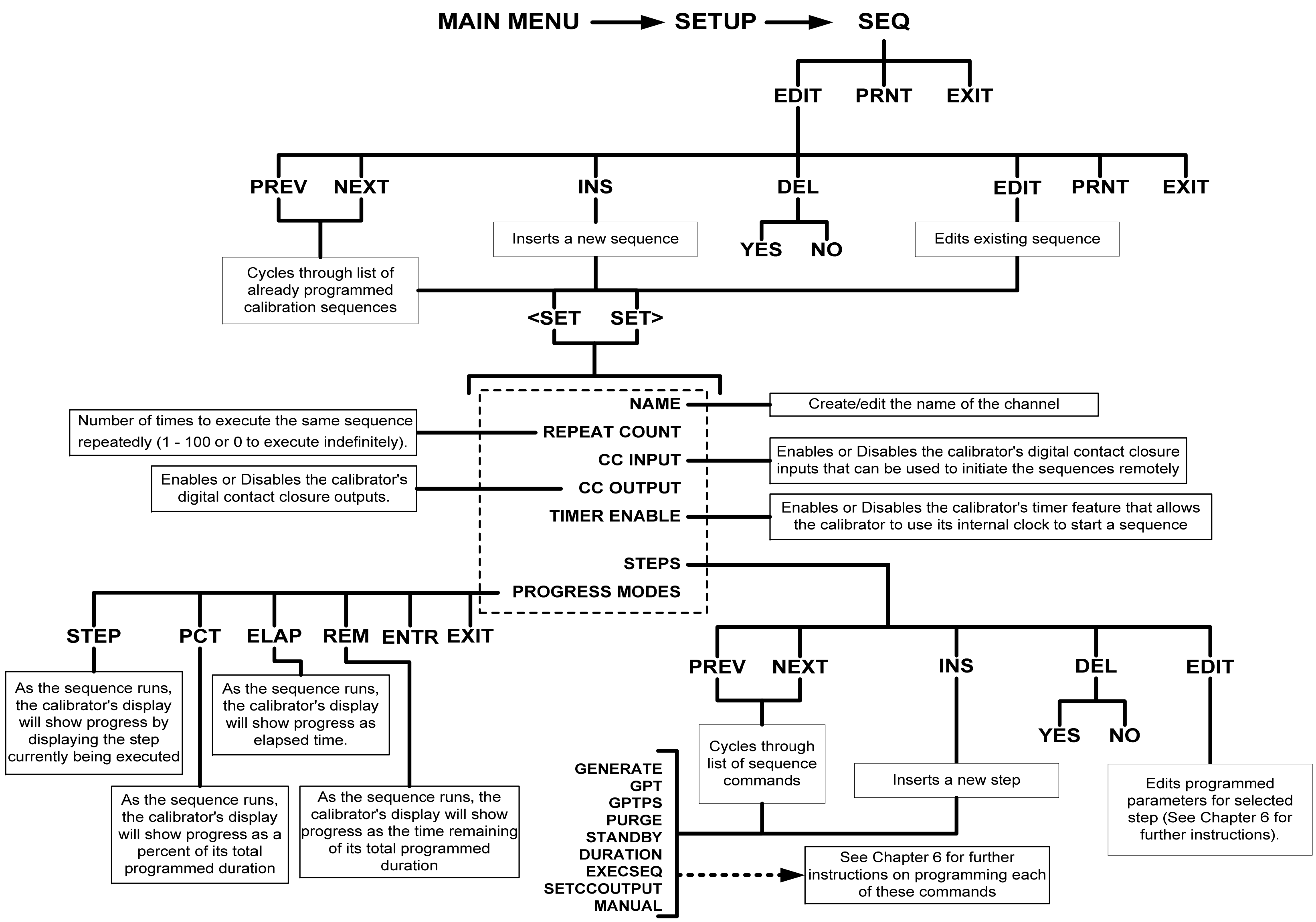


Figure A-5: PRIMARY SETUP Menu - SEQUENCE CONFIGURATION Submenu

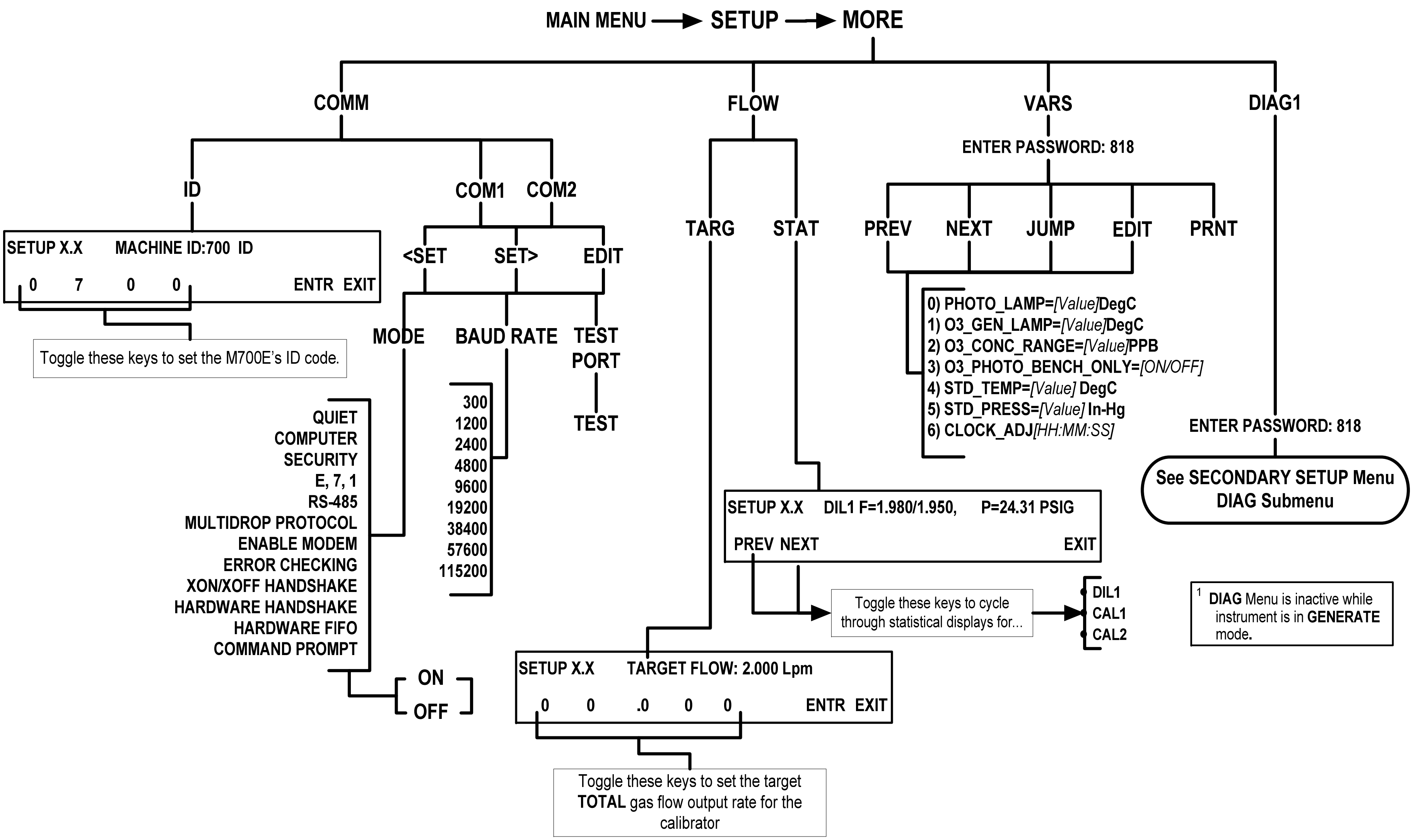


Figure A-6: SECONDARY SETUP Menu - Basic)

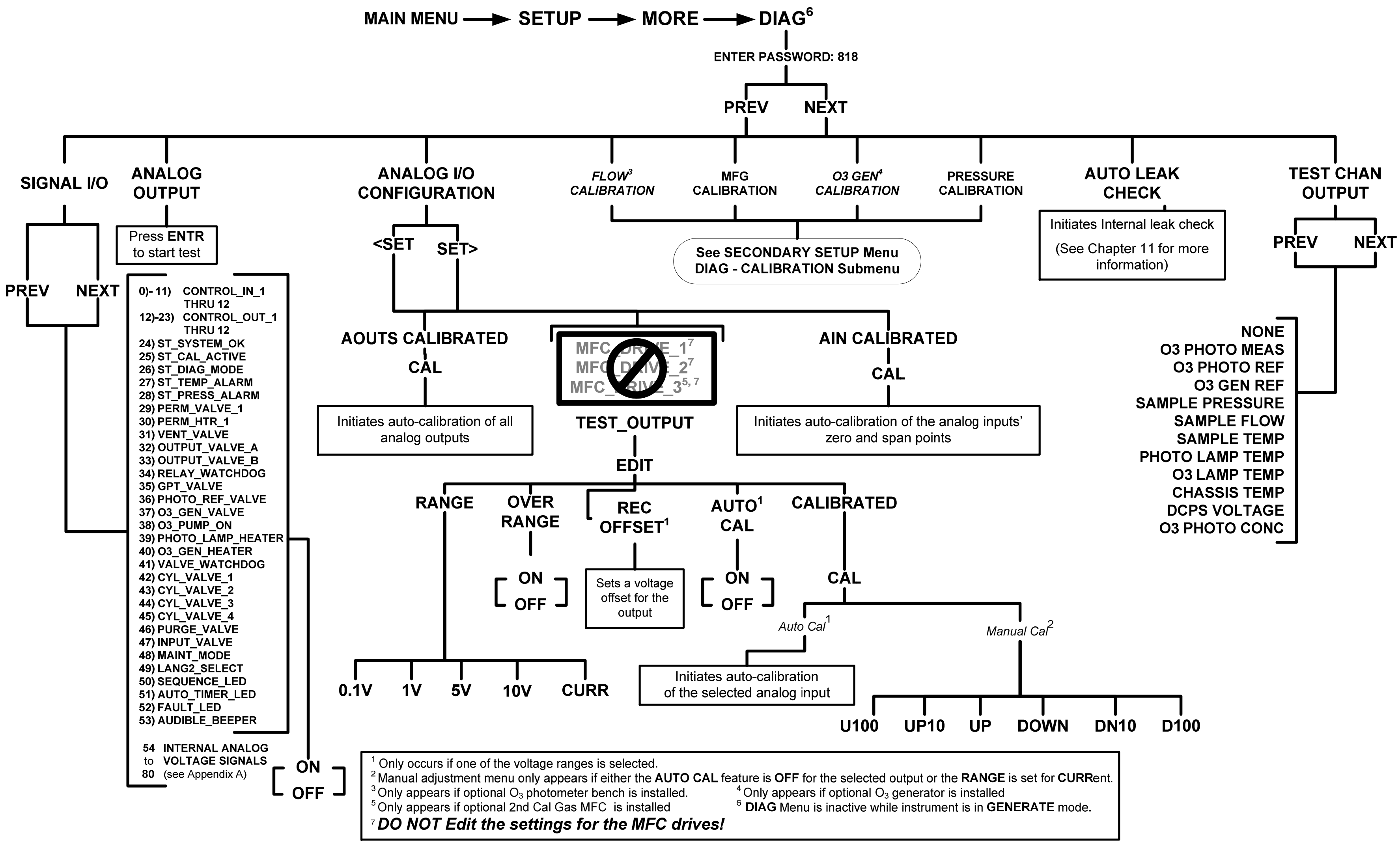
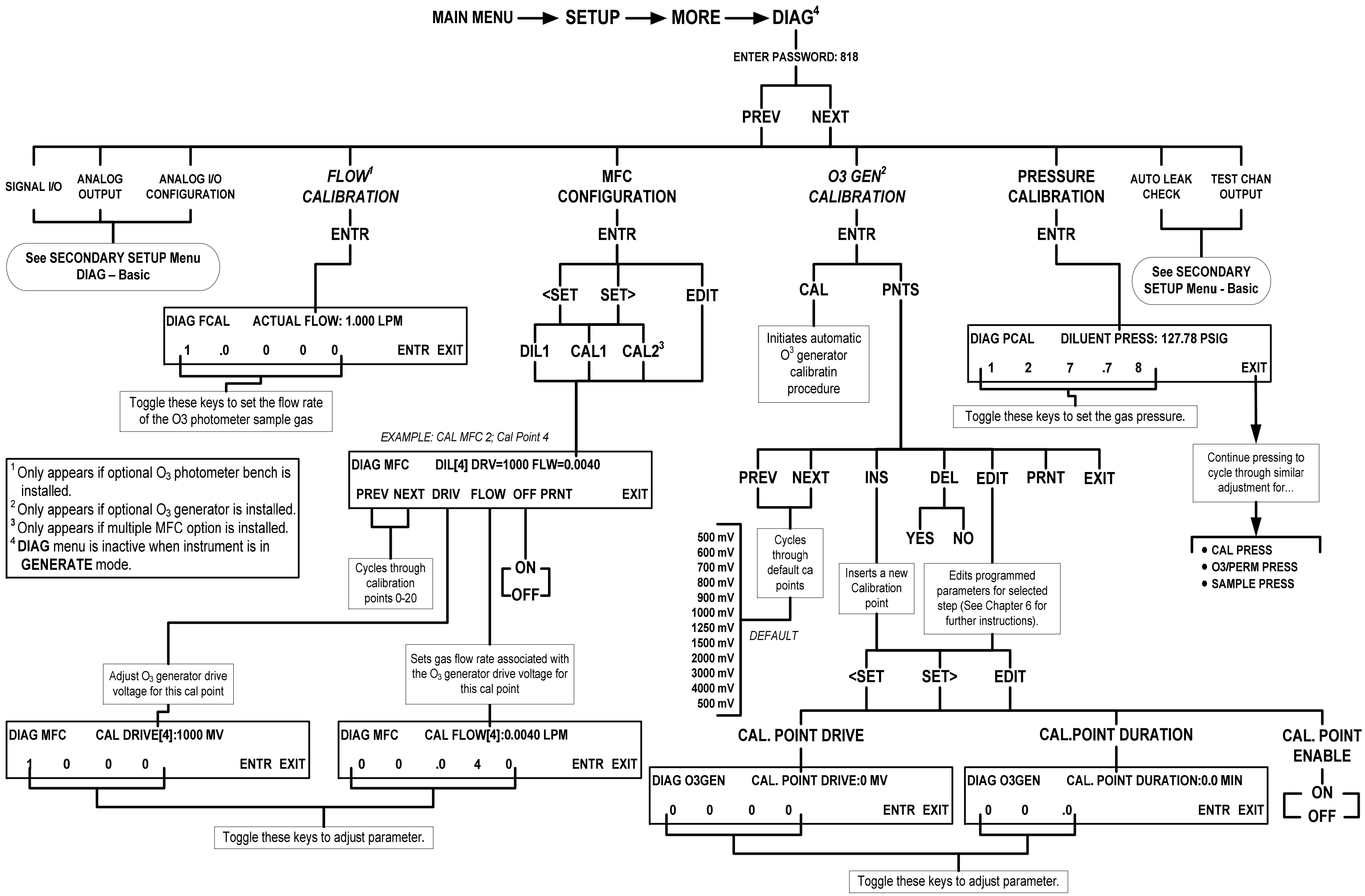


Figure A-7: SECONDARY SETUP Menu; DIAG Submenu – Basic



4. QUICK CALIBRATION

4.1 ANALOG CALIBRATION

1. The Calibrator must be in STANDBY.
2. From the Main Menu press [SETUP] [MORE] [DIAG] [929] [ENTR] [NEXT] [ANALOG I/O CONFIGURATION] [ENTER] [CAL]. This will calibrate all of the analog outputs.
3. From the Main Menu press [SETUP] [MORE] [DIAG] [929] [ENTR] [NEXT] [ANALOG I/O CONFIGURATION] [ENTER] [SET>] [AIN CALIBRATED] [CAL]. This will calibrate the Analog Inputs.
4. This calibration should always be done AUTOMATICALLY never MANUALLY.

4.2 PRESSURE/FLOW CALIBRATIONS

4.2.1 DILUTION PRESSURE CALIBRATION

1. The Calibrator must be in STANDBY.
2. Disconnect the ¼” line that runs to the Dilution MFC and attach a pressure gauge to this piece of tubing.
3. Press [SETUP] [MORE] [DIAG] [929] [ENTER].
4. Press [NEXT] until the top line reads PRESSURE CALIBRATION press [ENTER].
5. Adjust the inlet pressure until it is exactly 30 PSI on the gauge by adjusting the regulator of the pressure source(M701, compressor or Bottle)
6. Leave every pressure except the Dilution Pressure the same.
7. Set the DILUTION PRESSURE setting to exactly 30PSI and then press [ENTER].
8. This calibration should always be done AUTOMATICALLY never MANUALLY.

4.2.2 CAL GAS PRESSURE CALIBRATION

1. The Calibrator must be in STANDBY.
2. Disconnect the ¼” line that runs to the CAL GAS MFC and attach a pressure gauge to this piece of tubing.
3. Press [SETUP] [MORE] [DIAG] [929] [ENTER].
4. Press [NEXT] until the top line reads PRESSURE CALIBRATION press [ENTER].
5. Adjust the inlet pressure until it is exactly 30 PSI on the gauge by adjusting the regulator of the pressure source (M701, compressor or Bottle).
6. Leave every pressure except the CAL GAS PRESSURE the same.
7. Set the CAL GAS PRESSURE to exactly 30PSI and press ENTER.

4.2.3 REGULATOR PRESSURE CALIBRATION

THIS CALIBRATION IS ONLY PERFORMED IF THE CALIBRATOR HAS THE OZONE GENERATOR OPTION OR PERM TUBE OPTION INSTALLED

1. The Calibrator must be in STANDBY.
2. Disconnect the ¼” TYGON line that runs from the PRESSURE REGULATOR to the PRESSURE SENSOR and attach a pressure gauge to this piece of tubing.
3. Press [SETUP] [MORE] [DIAG] [929] [ENTER].
4. Press [NEXT] until the top line reads PRESSURE CALIBRATION press [ENTER].
5. Adjust the screw on the REGULATOR until the pressure gauge reads exactly 20 PSI on the gauge.
6. Connect the tubing back up to the regulator
7. Leave every pressure except the O3/PERM pressure setting the same.
8. Set the O3/PERM pressure setting to exactly 20PSI and press [ENTER].

4.2.4 PHOTO PRESSURE CALIBRATION

THIS CALIBRATION IS ONLY PERFORMED IF THE CALIBRATOR HAS THE PHOTOMETER OPTION INSTALLED.

1. The Calibrator must be in STANDBY.
2. Find the current local ambient pressure in INCHES HG, from either a local weather station or a calibrated barometer.
3. Press [SETUP] [MORE] [DIAG] [929] [ENTER].
4. Press [NEXT] until the top line reads PRESSURE CALIBRATION press [ENTER].
5. Leave every pressure except the SAMPLE pressure setting the same.
6. Set the SAMPLE pressure setting to the current local ambient pressure and press [ENTER]

4.2.5 PHOTO FLOW CALIBRATION

THIS CALIBRATION IS ONLY PERFORMED IF THE CALIBRATOR HAS THE PHOTOMETER OPTION INSTALLED.

1. Generate 0ppb of O3.
2. Remove the sample fitting on the O3 bench and measure the O3 flow going into the Teflon Elbow.
3. This flow rate should be 800cc/min ±80cc's. Reconnect the sample fitting.
4. Now put the calibrator into STANDBY.
5. Press [SETUP] [MORE] [DIAG] [929] [ENTER]. Press [NEXT] until the top line reads FLOW CALIBATION press [ENTER]
6. Enter the measured flow in step 2 above. Press [ENTER].
7. EXIT out to the main menu and generate 0ppb of ozone.
8. Press the <TST TST> buttons until the top line reads PHOTO FLOW. This should read the measure value that was entered in step 6
9. The calibration is complete.
10. EXIT back out to the Main Menu and ensure that the flow is correct.

4.3 MFC CALIBRATIONS

DO NOT USE THE MFC AUTO-CALIBRATION

4.3.1 DILUENT MFC CALIBRATION

1. The calibrator must be in STAND BY.
2. Connect a calibrated flow meter to the outlet of the DILUTION MFC.
3. Connect a SOURCE of ZERO AIR to the DILUENT IN and TEE it to CYL 1 port on the rear panel of the instrument.
4. From the Main Menu press [SETUP] [MORE] [DIAG] [929] [ENTER].
5. Press [NEXT] until the top line reads MFC CONFIGURATION and then press [ENTER]
6. Press [EDIT], press the SET> button until the top line reads DIL1 TABLE.
7. Press [EDIT].
8. Press the [OFF] button to turn ON the flow to the MFC. Record the flow reading on your flow meter.
9. Press [ON] button to turn OFF the flow.
10. Press [FLOW] and enter the FLOW that was recorded in step 7.

11. Press [NEXT] and repeat steps 8-11 until all 20 points are done.
12. When completed press [EXIT]
13. It will prompt you to SAVE select YES.
14. The MFC calibration is completed.
15. [EXIT] out to the main menu.

4.3.2 CAL GAS MFC CALIBRATION

1. The calibrator must be in STAND BY.
2. Connect a calibrated flow meter to the outlet of the CAL GAS MFC.
3. Connect a SOURCE of ZERO AIR to the DILUENT IN and TEE it to CYL 1 port on the rear panel of the instrument.
4. From the Main Menu press [SETUP] [MORE] [DIAG] [929] [ENTER].
5. Press [NEXT] until the top line reads MFC CONFIGURATION and then press [ENTER]
6. Press the SET> button until the top line reads CAL1.
7. Press [EDIT].
8. Press the SET> button until the top line reads CAL1 table.
9. Press [EDIT].
10. Press the [OFF] button to turn ON the flow to the MFC. Record the flow reading on your flow meter.
11. Press [ON] button to turn OFF the flow.
12. Press [FLOW] and enter the FLOW that was recorded in step 10.
13. Press [NEXT] and repeat steps 8-11 until all 20 points are done.
14. When completed press [EXIT]
15. It will prompt you to SAVE select YES.
16. The MFC calibration is completed.
17. [EXIT] out to the main menu.

4.4 OZONE CALIBRATIONS

4.4.1 REFERENCE ADJUSTMENT

1. Put the calibrator into STANDBY.
2. Press [SETUP] [GAS] [O3] [ADJ].
3. Press the <TST TST> buttons until O3 GEN DRIVE, this value should be 2500mv.
4. Press the <TST TST> buttons until O3 GEN REF, this value should be 2500mv ±200mv. If it is not you will need to peak the UV LAMP and adjust the reference detector potentiometer VR1 until the value is within specifications.
5. Exit back to the Main Menu.

4.4.2 BENCH CALIBRATION

1. The calibrator must be in STANDBY mode.
2. Press [SETUP] [GAS] [O3] [PHOT] [BCAL] [717] [ENTER] [CAL] [ZERO] [ENTER], wait 30 minutes until you have a good stable zero reading on your photometer and then press [ZERO] [YES], the Zero has now been calibrated. Press [EXIT] one time.
3. Press [CAL] [SPAN] [ENTER]
4. Select your target concentration and press [ENTER] and wait 30 minutes for the photometer become stable.

5. Press [SPAN], enter the amount of ozone read by your photometer and then press [ENTER] [YES].
6. The internal photometer reading should now match your external photometer reading.
7. Exit back to the Main Menu.

4.4.3 IZS CALIBRATION

1. The calibrator must be in STAND BY.
2. Press [SETUP] [MORE] [DIAG] [929] [NEXT] until the top line reads O3 GEN CALIBRATION.
3. Press [ENTER] [CAL]
4. This procedure will be performed automatically and take 1 hour to complete.
5. Once the calibration has been completed exit back out to the main menu.

4.5 USING THE M700E AS A PHOTOMETER

4.5.1 The M700E will normally generate its own ozone levels and read that, adjusting for the proper concentration requested. However; there is a new feature that allows you to use the M700E as a photometer, monitoring external ozone concentrations.

To do this simply remove the two U shaped tubing jumpers on the back of the calibrator. You will now plumb your ozone to the "PHOTOMETER INLET" (Measure) and your Zero Air to the "PHOTO ZERO INLET" (Reference). Make sure that both of these are at ambient pressure use a vent to ensure that these are at ambient.

Once this has been plumbed up simply hit [GEN] [AUTO] [0ppb O3]. The calibrator will now act as though it is generating ozone except it will be pulling gas from the outside of the calibrator. From the front panel press the <TST TST> buttons until the top line reads ACT=, this will be displaying the current ozone concentration

5. MAINTENANCE

5.1 MAINTENANCE

5.1.1 DUE TO THE M700E CALIBRATOR RECEIVING CLEAN DRY CAL GAS AND CLEAN DRY ZERO AIR THERE IS NO MAINTENANCE REQUIRED.

6. LEAKCHECKING

6.1 LEAK CHECK PROCEDURE

WITH PHOTOMETER OPTION

1. In order to perform a leak check if the calibrator has the photometer option the photometer must be bypassed.
2. Bypass the photometer by using a #6 nut driver and removing the Hexagonal shaped screw located at the inlet of the photometer bench. Figure **6.2.1**
3. Using a #6 nut driver remove the hexagonal shaped screw and tubing located on the fitting on the back side of the Flow/Pressure sensor board (figure **6.2.1**) and reconnect it to the inlet fitting on the photometer bench.
4. Cap the Vent on the tee that is located inside on at the PHOTOMETER ZERO IN port on the rear panel. Refer to **FIGURE 6.2.3**
5. Cap the Exhaust, Cal Gas out ports (2) and the Vent port on the rear panel. Refer to **FIGURE 6.2.2**
6. Remove any bottle from CYL 1 port on the rear panel. Ensure that the bottle is turned off before disconnecting.
7. Connect a line from the Zero Air Source and tee it to the Diluent Gas In and to the Cylinder 1 Port. Refer to **FIGURE 6.2.2**
8. From the Main Menu ensure that the instrument is on STANDBY. Press SETUP-MORE-DIAG-929-ENTR.
9. Press NEXT until the top line reads AUTO LEAK CHECK. Press ENTR. The leak check will start automatically and will last approximately 5 minutes to complete.
10. A FAIL indication at the end of the test will determine whether or not you will need to troubleshoot the instrument for leaks.
11. A PASS indication at the end of the test informs you that the calibrator is free of any major leaks.
12. Remove the caps from the EXHAUST, CAL GAS OUTPUTS (2) and the VENT port.
13. Remove the tee from the DILUENT IN and CYL 1.
14. Reconnect the ZERO AIR SOURCE to the DILUENT IN.
15. Reconnect Cal Gas bottle to CYL 1 and turn on bottle.
    a. Remove the cap from the photometer "T".
    b. Remove the fitting from photometer bench inlet and connect to fitting on the back side of the pressure flow sensor board.
    c. Replace hexagonal shaped screw and tubing onto photometer inlet fitting.
16. The calibrator is now ready to be used.

FIGURE 6.2.1

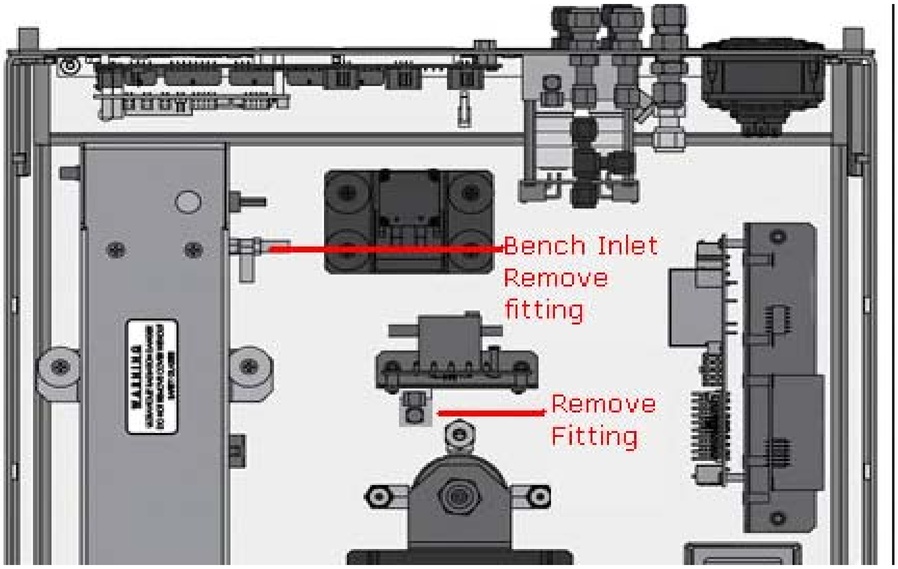


FIGURE 6.2.2

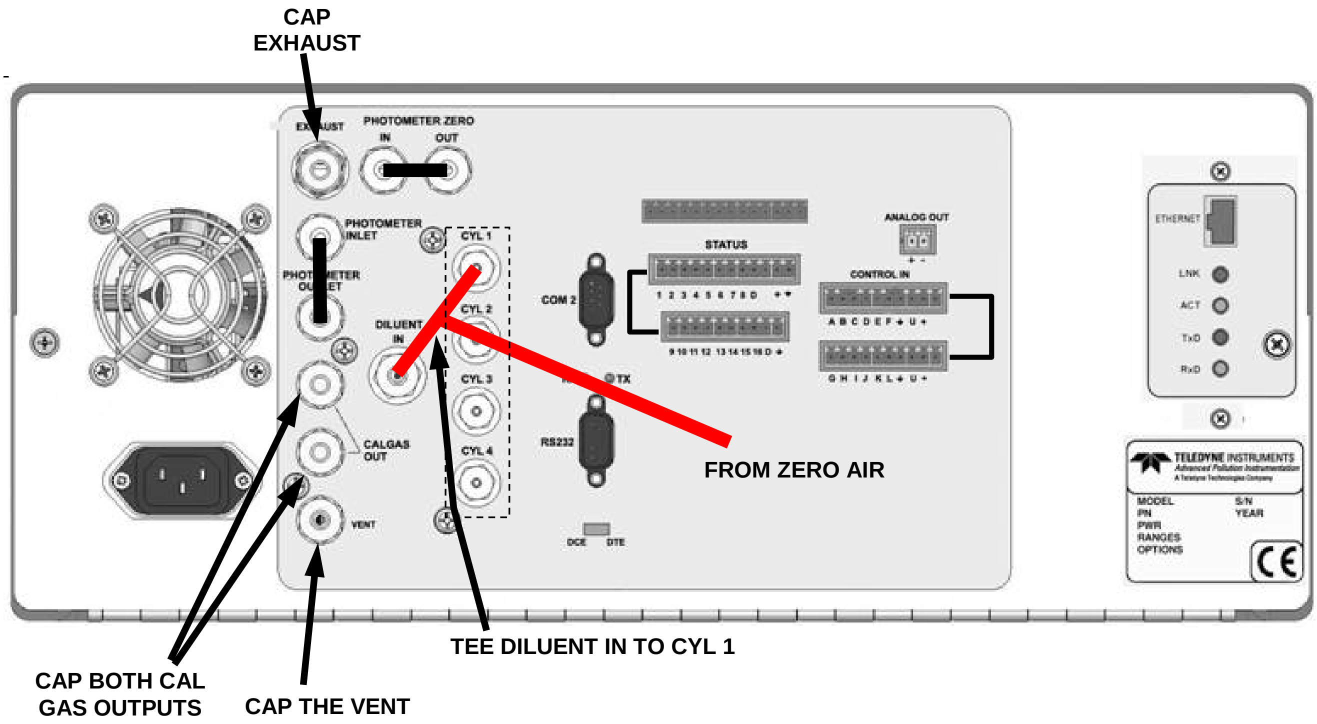
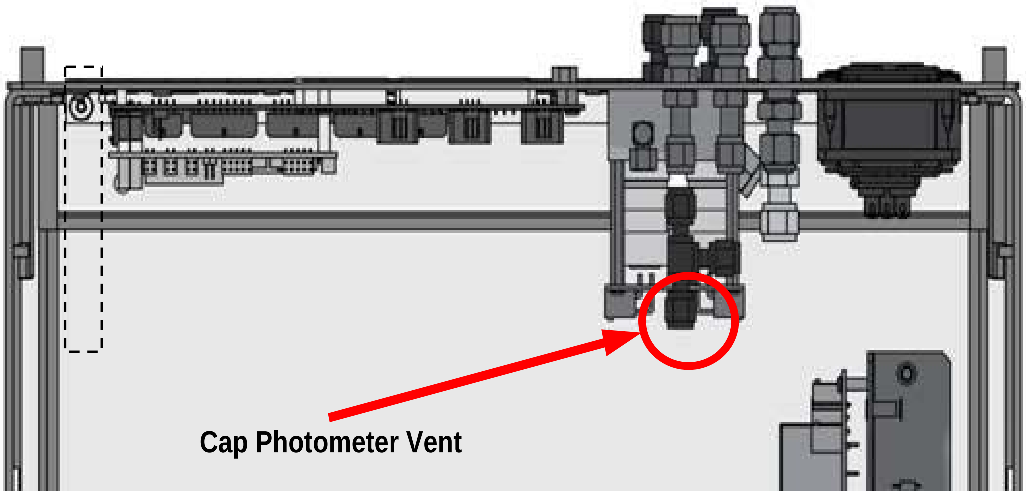


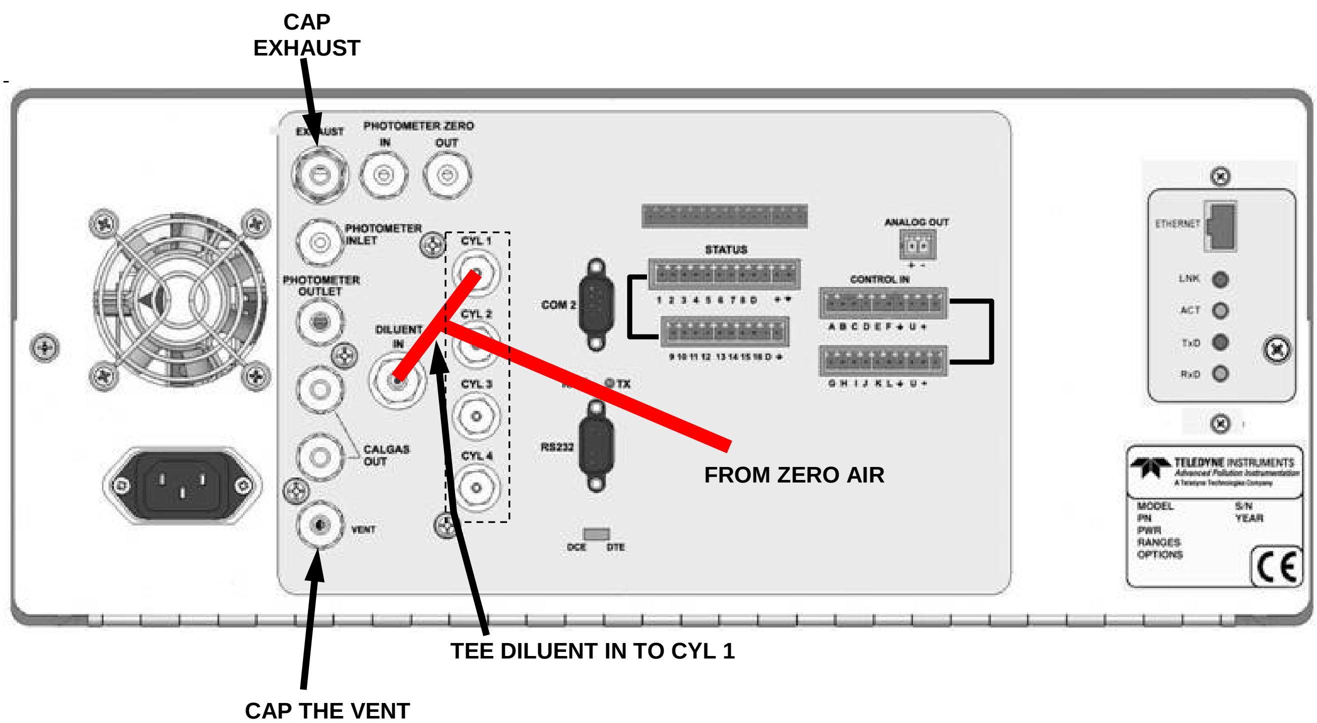
FIGURE 6.2.3



6.2 LEAK CHECK PROCEDURE (NO OPTIONS)

1. Cap the Exhaust and all vent fittings.
2. Remove any bottle that is connected to CYL 1. Ensure that the bottle is turned off before disconnect the tubing from the port.
3. Connect the Zero Air Source to the Diluent IN and CYL 1 on the rear panel by using a tee. Refer to **Figure 6.2.4.1**
4. From the main menu press SETUP-MORE-DIAG-ENTR press NEXT until AUTO LEAK CHECK.
5. Press ENTR. The leak check will be performed automatically and last approximately 5 Minutes.
6. A FAIL indication at the end of the test will inform you if you should troubleshoot the instrument for leaks.
7. If the instrument passes the AUTO LEAK CHECK. Remove all caps.
8. Reconnect the bottle of gas removed in step 2. Turn on the bottle of gas.
9. The instrument can now be used.

FIGURE 6.2.4.1



7. SPECIFICATIONS

Specifications, Approvals and Warranty

7.1.1 Specifications

Table 7-1: M700E Dilution System Specifications

Flow Measurement Accuracy	±1% F.S.
Repeatability of Flow Control	±0.2% F.S.
Linearity of Flow Measurement	±0.5% F.S.
Flow Range of Diluent Air	0 to 10 SLPM – Optional Ranges: 0 to 5 SLPM; 0 to 20 SLPM
Flow Range of Cylinder Gases	0 to 100 cc/min – Optional Ranges: 0 to 50 cc/min; 0 to 200 cc/min
Zero Air Required	10 SLPM @ 30 PSIG Optional: 20 SLPM @ 30 PSIG
CAL gas input ports	4 (configurable)
Diluent Gas Input Ports	1
Response Time	60 Sec. (98%)

Table 7-2: M700E Dilution Electrical and Physical Specifications

Temperature Range	5-40°C
Humidity Range	0 - 95% RH, non-condensing
Dimensions (HxWxD)	7" (178 mm) x 17" (432 mm) x 24" (609 mm)
Operating Altitude	10,000 ft Maximum
Weight	29 lbs (13.1 kg); 39 lbs. (17.7 kg) including optional photometer, GPT, and 03 generator
AC Power	85VAC to 264VAC 47Hz to 63Hz.
Analog Outputs	1 user configurable output
Analog Output Ranges	All Outputs: 0.1 V, 1 V, 5 V or 10 V Range with 5% under/over-range
Analog Output Resolution	1 part in 4096 of selected full-scale voltage (12 bit)
Digital Control Outputs	12 opto-isolated outputs
Digital Control Inputs	12 opto-isolated outputs
Status Outputs	12 opto-isolated outputs, 5 defined, 7 spare
Serial I/O	2 ports: 1x RS-232; 1x RS-485 or RS-232 (configurable) Communication speed: 300 - 115200 baud (user selectable)
Certifications	EN61326 (1997 w/A1: 98) Class A, FCC Part 15 Subpart B Section 15.107 Class A, ICES-003 Class A (ANSI C63.4 1992) & AS/NZS 3548 (w/A1 & A2; 97) Class A. IEC 61010-1:90 + A1:92 + A2:95,

Table 7-3: M700E Specifications for Optional Ozone Generator

Maximum Output	6ppm LPM
Minimum Output	100ppb LPM
Response Time:	180 Sec. (98%)
Optical Feedback	Standard
Stability (7-days)	1% with optional photometer; 3% without photometer
Linearity	1% with optional photometer; 3% without photometer

Table 7-4: M700E Specifications for Optional O_3 Photometer

Full Scale Range	100ppb to 10ppm ; User Selectable
Precision	1.0ppb
Linearity	1.0% of reading
Rise/Fall Time	<20 sec (photometer response)
Response Time (98%)	180 sec. (system response)
Zero Drift	<1.0ppb / 7 days
Span Drift	<1% / 24 hours; <2% / 7 days

8. WARNINGS AND TEST FUNCTIONS

TABLE 8-1 FRONT PANEL WARNING MESSAGES

WARNING	FAULT CONDITION	POSSIBLE CAUSES
CONFIG INITIALIZED	Configuration and Calibration data reset to original Factory state.	- Failed Disk on Chip - User has erased configuration data
DATA INITIALIZED	Data Storage in iDAS was erased.	- Failed Disk-on-Chip. - User cleared data.
FRONT PANEL WARN	The CPU is unable to Communicate with the Front Panel Display Keyboard	- *WARNING* only appears on Serial I/O COM Port(s) - Front Panel Display will be frozen, blank or will not respond. - Failed Keyboard - I^2C Bus failure - Loose Connector/Wiring
LAMP DRIVER WARN[1, 2]	The CPU is unable to communicate with either the O_3 generator or photometer lamp I2C driver chip.	- I^2C has failed
MFC COMMUNICATION WARNINBG	Firmware is unable to communicate with any MFC.	- I^2C has failed - One of the MFC's has failed - Cabling loose or broken between MFC and Motherboard
MFC PRESSURE WARNING	One of the calibrator's mass flow controllers internal gas pressure is <15 PSIG or > 36 PSIG	- Zero or source air supply is incorrectly set up or improperly vented. - Leak or blockage exists in the M700E's internal pneumatics - Failed CAL GAS or DUILUENT pressure sensor
O3 GEN LAMP TEMP WARNING[1]	IZS Ozone Generator Temp is outside of control range of 48°C ± 3°C.	- No IZS option installed, instrument improperly configured - O_3 generator heater - O_3 generator temperature sensor - Relay controlling the O_3 generator heater - Entire Relay PCA - I2C Bus
O3 GEN REFERENCE WARNING[1]	The O_3 generator's reference detector output has dropped below 50 mV.[1]	Possible failure of: - O_3 generator UV Lamp - O_3 generator reference detector - O_3 generator lamp power supply - I^2C bus
O3 PUMP WARNING[1]	The photometer pump failed to turn on within the specified timeout period (default = 30 sec.).	- Failed Pump - Problem with Relay PCA - 12 VDC power supply problem
PHOTO LAMP TEMP WARNING[2]	The photometer lamp temp is < 51°C or >61°C.	Possible failure of: - Bench lamp heater - Bench lamp temperature sensor - Relay controlling the bench heater - Entire Relay PCA - I^2C Bus - Hot" Lamp

TABLE 8-1 (CONT) FRONT PANEL WARNING MESSAGES

WARNING	FAULT CONDITION	POSSIBLE CAUSES
PHOTO LAMP STABILITY WARNING	Value output during the Photometer's reference cycle changes from measurements to measurement more than 25% of the time.	- Faulty UV source lamp - Noisy UV detector - Faulty UV lamp power supply - Faulty ± 15 VDC power supply
PHOTO REFERENCE WARNING[2]	Occurs when Ref is <2500 mVDC or >4950 mVDC.	Possible failure of: - UV Lamp - UV Photo-Detector Preamp
REAR BOARD NOT DET	Mother Board not detected on power up.	- THIS WARNING only appears on Serial I/O COM Port(s) Front Panel Display will be frozen, blank or will not respond. - Failure of Mother Board
REGULATOR PRESSURE WARNING	Regulator pressure is > 15 PSIG or > 25 PSIG.	- Zero or source air supply is incorrectly set up or improperly vented. - Incorrectly adjusted O_3 zero air pressure regulator - Leak or blockage exists in the M700E's internal pneumatics - Failed O_3 Generator Input pressure sensor
RELAY BOARD WARN	The CPU cannot communicate with the Relay PCA.	- I^2C Bus failure - Failed relay PCA - Loose connectors/wiring
SYSTEM RESET	The computer has rebooted.	- This message occurs at power on. - If it is confirmed that power has not been interrupted: - Failed +5 VDC power - Fatal error caused software to restart - Loose connector/wiring
VALVE BOARD WARN	The CPU is unable to communicate with the valve board.	- I^2C Bus failure - Failed valve driver PCA - Loose connectors/wiring

[1] Only applicable for calibrators with the optional the O_3 generator installed.
[2] Only applicable for calibrators with the optional photometer installed.
[3] On instrument with multiple Cal Gas MFC's installed, the **MFC FLOW WARNING** occurs when the flow rate requested is <10% of the range of the lowest rated MFC (i.e. all of the cal gas MFC are turned off).

TABLE 8-2 FRONT PANEL TEST FUNCTIONS (INDICATED FAILURES)

TEST FUNCTION	DIAGNOSTIC RELEVANCE AND CAUSES OF FAULT CONDITIONS.
O3 GEN REF[1]	Particularly important in calibrators without the optional O_3 photometer since the reference detector is the primary input for controlling O_3 concentration.
O3 FLOW[1]	Gas flow problems directly affect the concentration accuracy of the M700E's calibration gas mixtures. - Check for Gas Flow problems.
O3 GEN DRIVE[1]	Check the O_3 generator heater and temperature sensors
O3 LAMP TEMP[1]	Incorrect Lamp temperature can affect the efficiency and durability of the O_3 generators UV lamp.
CAL PRESSURE	Affects proper flow rate of Cal gas MFC's.
DIL PRESSURE	Affects proper flow rate of Diluent gas MFC's.
REG PRESSURE[2]	Same as **REGULATOR PRESSURE WARNING** from
BOX TEMP	If the Box Temperature is out of range, make sure that the: Box Temperature typically runs ~7°C warmer than ambient temperature. - The Exhaust-Fan is running - Make sure there is sufficient ventilation area to the side and rear of instrument to allow adequate ventilation.
PHOTO MEASURE[2] & **PHOTO REFERENCE**[2]	If the value displayed is too high the UV Source has become brighter. Adjust the variable gain potentiometer on the UV Preamp Board in the optical bench. If the value displayed is too low: - < 100mV – Bad UV lamp or UV lamp power supply. - < 2000mV – Lamp output has dropped, adjust UV Preamp Board or replace lamp. If the value displayed is constantly changing: - Bad UV lamp. - Defective UV lamp power supply. - Failed I^2C Bus. If the PHOTO REFERENCE value changes by more than 10mV between zero and span gas: - Defective/leaking switching valve.
PHOTO FLOW[2]	Gas flow problems directly affect the accuracy of the photometer measurements and therefore the concentration accuracy of cal gas mixtures involving O_3 and GPT mixtures. - Check for Gas Flow problems.
PHOTO LAMP TEMP[2]	Poor photometer temp control can cause instrument noise, stability and drift. Temperatures outside of the specified range or oscillating temperatures are cause for concern.
PHOTO SPRESS[2]	The pressure of the gas in the photometer's sample chamber is used to calculate the concentration of O_3 in the gas stream. Incorrect sample pressure can cause inaccurate readings. - Check for Gas Flow problems.
PHOTO STEMP[2]	The temperature of the gas in the photometer's sample chamber is used to calculate the concentration of O_3 in the gas stream. Incorrect sample temperature can cause inaccurate readings. Possible causes of faults are: - Bad bench lamp heater - Failed sample temperature sensor - Failed relay controlling the bench heater - Failed Relay PCA - I^2C Bus malfunction

TABLE 8-2 (CONT) FRONT PANEL TEST FUNCTIONS (INDICATED FAILURES)

TEST FUNCTION	DIAGNOSTIC RELEVANCE AND CAUSES OF FAULT CONDITIONS.
PHOTO STEMP[2]	The temperature of the gas in the photometer's sample chamber is used to calculate the concentration of O_3 in the gas stream. Incorrect sample temperature can cause inaccurate readings. Possible causes of faults are: - Bad bench lamp heater - Failed sample temperature sensor - Failed relay controlling the bench heater - Failed Relay PCA - I^2C Bus malfunction - Hot Lamp
PHOTO SLOPE[2]	Values outside range indicate: ▪ Contamination of the Zero Air or Span Gas supply. ▪ Instrument is miss-calibrated. ▪ Blocked Gas Flow. ▪ Faulty Sample Pressure Sensor or circuitry. ▪ Bad/incorrect Span Gas concentration.
PHOTO OFFSET[2]	Values outside range indicate: ▪ Contamination of the Zero Air supply.
TIME	Time of Day clock is too fast or slow. ▪ Battery in clock chip on CPU board may be dead.
[1] Only appears when the optional O_3 generator is installed. [2] Only appears when the optional O_3 photometer is installed	

9. LAYOUT

MODEL 700E CALIBRATOR

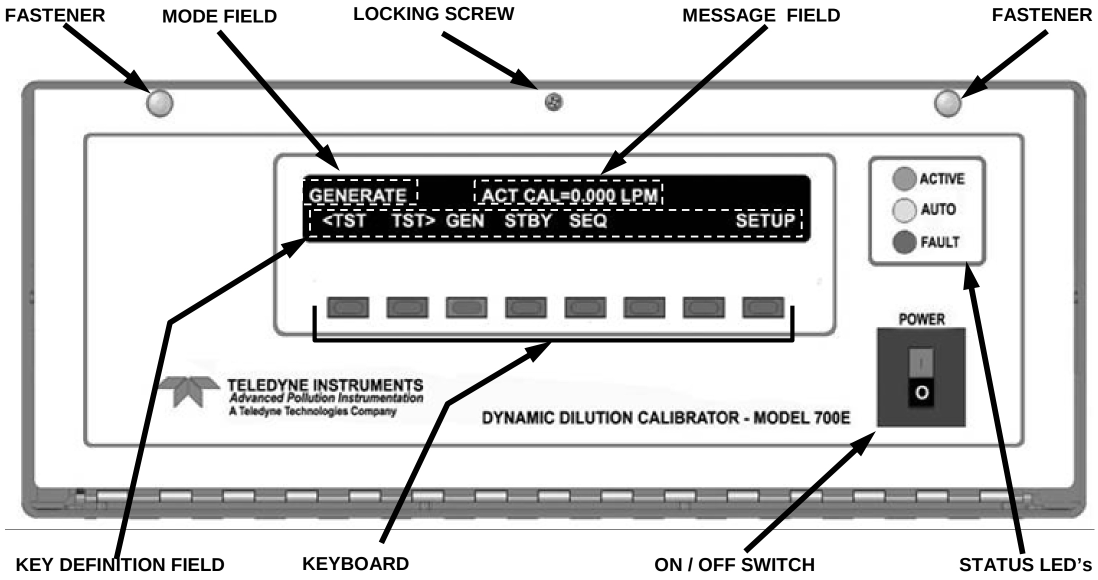


Figure 9-1: M700E Front Panel Layout

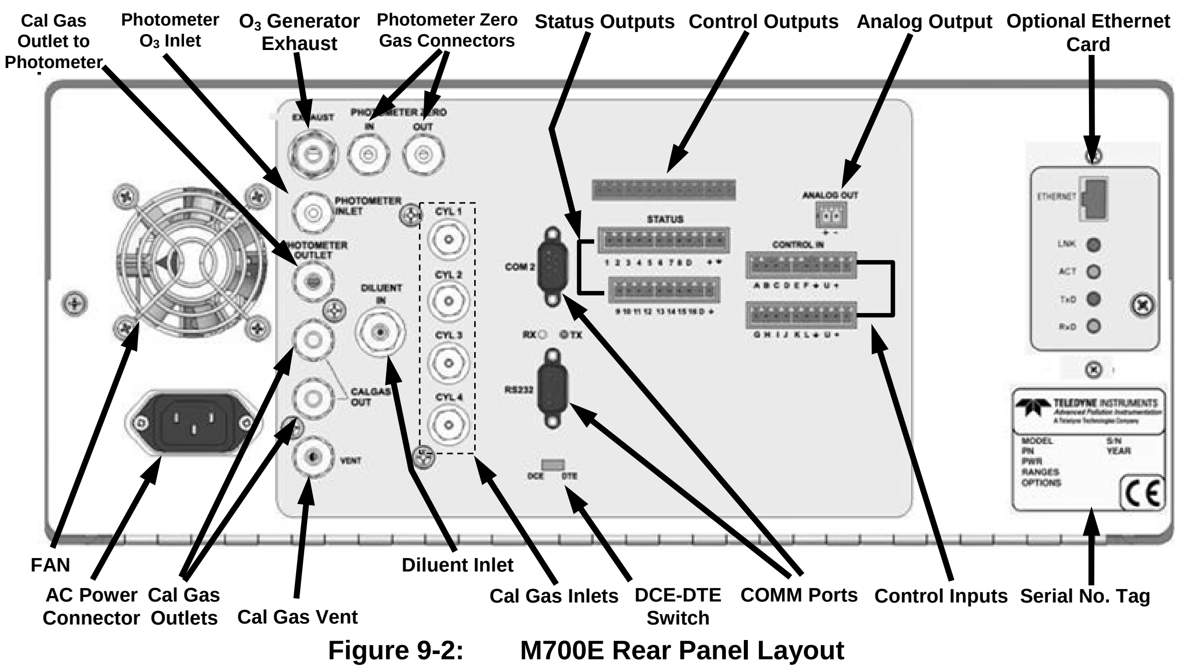


Figure 9-2: M700E Rear Panel Layout

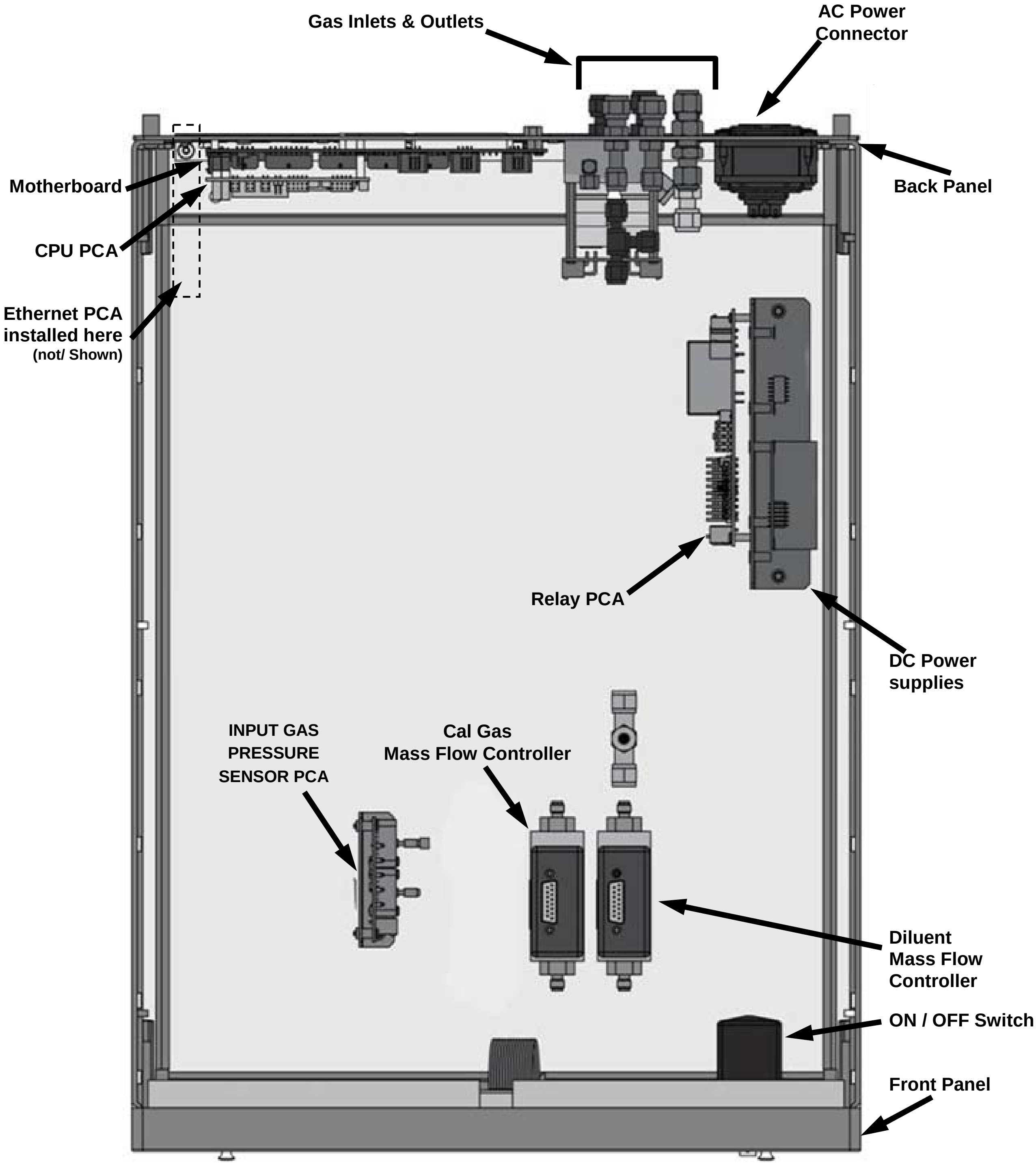


Figure 9-3: M700E Internal Layout – Top View – Base Unit

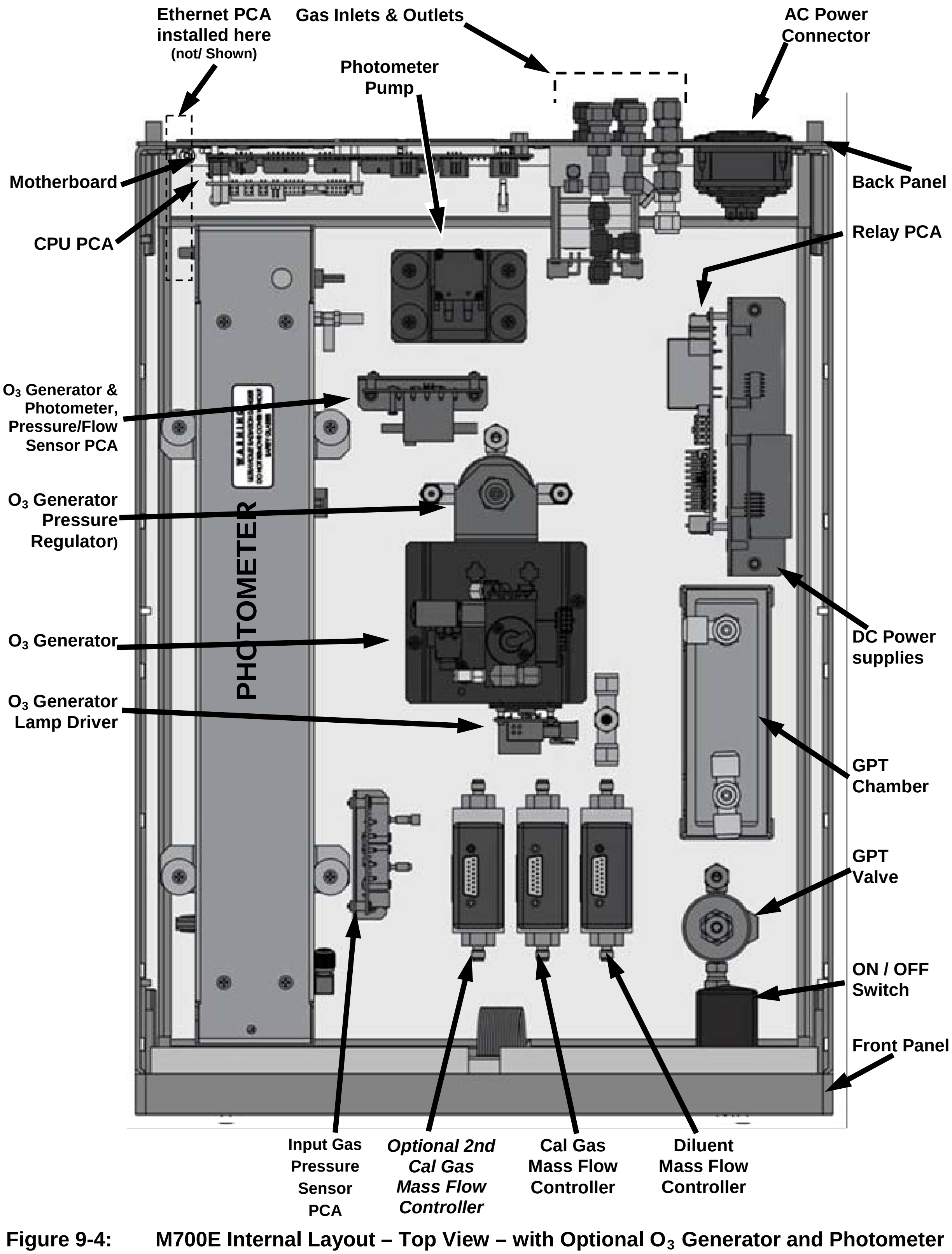


Figure 9-4: **M700E Internal Layout – Top View – with Optional O_3 Generator and Photometer**

10. OTHER OPTIONS

10.1.OZONE OPTIONS

10.1.1 INTERNAL OZONE GENERATOR (OPT 01)

Because ozone (O_3) quickly breaks down into molecular oxygen (O_2), this calibration gas can not be supplied in precisely calibrated bottles like other gases such as SO_2, CO, CO_2 NO, H_2S, etc. The optional O_3 generator extends the capabilities of the M700E Dynamic Dilution Calibrator dynamically generate calibration gas mixtures containing O_3.
Additionally a glass mixture volume, designed to meet US EPA guidelines for Gas Phase Titration (GPT), is included with this option. This chamber, in combination with the O_3 generator, allow the M700E to use the GPT technique to more precisely create NO_2 calibration mixtures

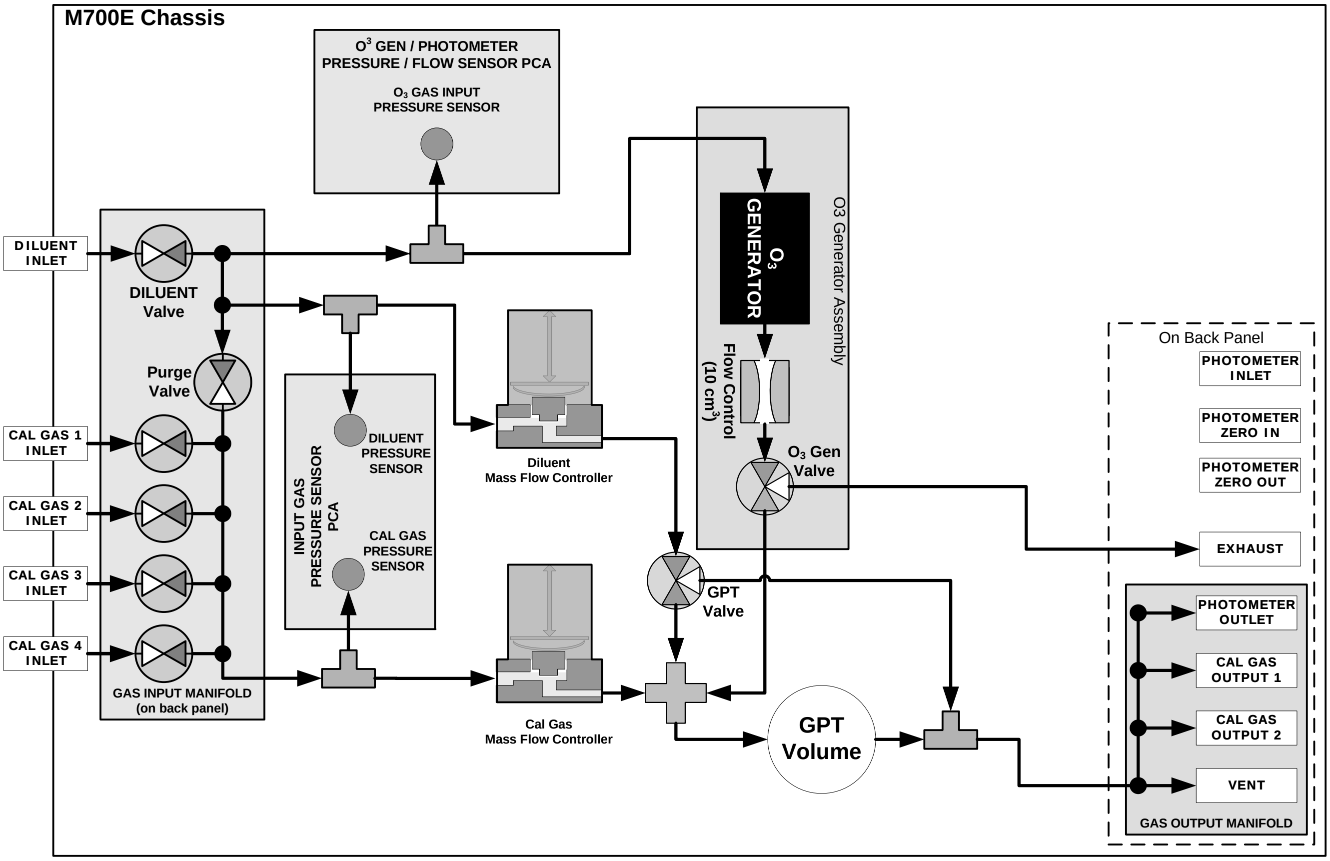


Figure 10-1: Internal Pneumatics for M700E calibrator with Optional O_3 Generator and GPT Chamber.

Table 10-1: Operating Mode Valve States for M700E calibrator with Optional O_3 Generator.

MODE	VALVES (X = Closed; O = Open)								MFC's		
	CYL1	CYL2	CYL 3	CYL4	PURGE	DILUENT	GPT	O_3 GEN	CAL1	CAL2[1]	DILUENT
Generate Source Gas	O[2]	O[2]	O[2]	O[2]	X	O	X	X	ON[3]	ON[3]	ON
Generate O_3	X	X	X	X	X	O	X	O	OFF	OFF	OFF
GPT	O[2]	O[2]	O[2]	O[2]	X	O	O	O	ON[3]	ON[3]	ON
GPTPS	X	X	X	X	X	O	O	O	OFF	OFF	ON
PURGE	X	X	X	X	O	O	O	O	ON[3]	ON[3]	ON
STANDBY	X	X	X	X	X	O	X	X	OFF	OFF	OFF

[1] Only present if multiple cal gas MFC option is installed.
[2] The valve associated with the cylinder containing the chosen source gas is open.
[3] In instrument with multiple MFC's the CPU chooses which MFC to use depending on the target gas flow requested.

The output of the O_3 generator can be controlled in one of two ways:

- CONSTANT mode: By selecting a specific, constant drive voltage (corresponding to a specific O_3 concentration) for the generator, or;
- REFERENCE mode: The user selects a desired O_3 concentration and the calibrator's CPU sets the intensity of the O_3 generator's UV lamp to an intensity corresponding to that concentration. The voltage output of a reference detector, also internal to the generator, is digitized and sent to the M700E's CPU where it is used as input for a control loop that maintains the intensity of the UV lamp at a level appropriate for the chosen set point.

10.1.2 U.V. PHOTOMETER MODULE (OPT 02)

The photometer option increases the accuracy of the M700E calibrator's optional O_3 generator.

The photometer's operation is based on the principle that ozone molecules absorb UV light of a certain wavelength. A mercury lamp internal to the photometer emits UV light at that wavelength. This light shines down a hollow glass tube that is alternately filled with sample gas (the measure phase), and zero gas (the reference phase). A detector, located at the other end of the glass tube measure the brightness of the UV light after it passes though the gas in the tube. The O_3 content of the gas is calculated based on the ratio the UV light intensity during the measure phase (O_3 present) and the reference phase (no O_3 present).

When photometer option is installed a third, more precise and stabile option, called the **BENCH** feedback mode, exists for controlling the output of the O_3 generator. In **BENCH** mode the intensity of the O_3 generator's UV lamp is controlled (and therefore the concentration of the O_3 created) by the M700E's CPU based on the actual O_3 concentration measurements made by the photometer.

This option requires that the O_3 generator (**OPT 01**) be installed.

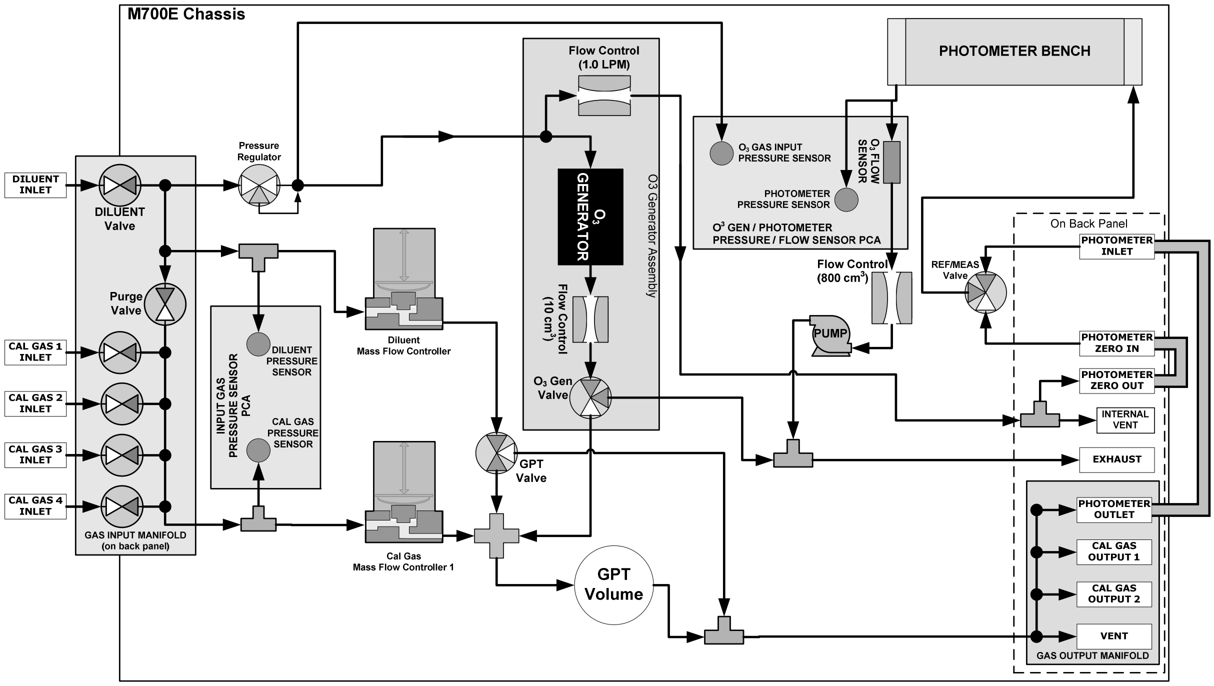


Figure 10-2: Internal Pneumatics for M700E calibrator with Optional O_3 Generator and Photometer.

Table 10-2: Operating Mode Valve States for M700E calibrator with Optional O_3 Generator and Photometer.

GAS TYPE	VALVES (X = Closed; O = Open)									MFC's			PHOT PUMP
	CYL1	CYL2	CYL 3	CYL4	PURGE	DILUENT	GPT	O_3 GEN	PHOT M/R	CAL1	CAL2[1]	DILUENT	
Generate Source Gas	O[2]	O[2]	O[2]	O[2]	X	O	X	X	Reference Phase	ON[3]	ON[3]	ON	OFF
Generate O_3	X	X	X	X	X	O	X	O	Switching	OFF	OFF	OFF	ON[4]
GPT	O[2]	O[2]	O[2]	O[2]	X	O	O	O	Reference Phase	ON[3]	ON[3]	ON	OFF
GPTPS	X	X	X	X	X	O	O	O	Switching	OFF	OFF	ON	ON[4]
PURGE	X	X	X	X	O	O	O	O	Reference Phase	ON[3]	ON[3]	ON	OFF
STANDBY	X	X	X	X	X	O	X	X	Reference Phase	OFF	OFF	OFF	OFF

[1] Only present if multiple cal gas MFC option is installed.
[2] The valve associated with the cylinder containing the chosen source gas is open.
[3] In instrument with multiple MFC's the CPU chooses which MFC to use depending on the target gas flow requested.
[4] When generating O_3 or in GPT Pre-Set mode, the photometer pump is the primary creator of gas flow through the M700E. Flow rates are controlled by critical flow orifice(s) located in the gas stream

10.2 GAS FLOW OPTIONS

10.2.1 FLOW RATE OPTIONS (OPT 07 & 08)

The standard M700E Dynamic Dilution Calibrator is equipped with one calibration gas mass flow controller and one diluent gas mass flow controller. Table 10-2 shows the flow rates for the standard M700E, as well as various flow rate options.

Table 10-2: M700E Gas Flow Rate Options

Option	Affected Mass Flow Controller	Flow rates	NOTES:
STANDARD	Cal/Source Gas MFC	0 – 100 cm^3/min	
	Diluent Gas MFC	0 – 10 LPM	
OPT – 07A	Cal/Source Gas MFC	0 – 50 cm^3/min	Replaces 0 – 100 cm^3/min Cal Gas MFC
OPT – 07B	Cal/Source Gas MFC	0 – 200 cm^3/min	Replaces 0 – 100 cm^3/min Cal Gas MFC
OPT – 08A	Diluent Gas MFC	0 – 20 LPM	Replaces 0 – 10 LPM Diluent Gas MFC
OPT –08B	Diluent Gas MFC	0 – 5 LPM	Replaces 0 – 10 LPM Diluent Gas MFC

10.2.2 MULTIPLE CALIBRATION SOURCE GAS MFC

This option adds an additional mass flow controller on the calibration gas stream. When this option is installed the M700E both calibration gas MFC's are on the same gas stream, installed in parallel (see Figures 10-3 and 10-4). The calibrator turns on the MFC with the lowest flow rate that can accommodate the requested flow and can therefore supply the most accurate flow control. When a flow rate is requested that is higher than the highest rated MFC (but lower than their combined maximum flow rating), both controllers are activated.

EXAMPLE:

- Calibrator with one calibration gas MFC configured for 0-5 LPM:

  Maximum gas flow = 5 LPM
  Minimum gas flow = 500 cm^3/min

- Calibrator with two calibration gas MFC's configured for 0-1 LPM and 0-5 LPM:

  Calibration gas flow rates:
  6 LPM; both MFC's active
  1.001 LPM – 5.000 LPM; High MFC active;
  10- cm^3/min – 1.000 LPM; Low MFC active

When this option is installed the test measurements that show the MFC actual and target flows (e.g **ACT CAL**; **TARG CAL**) show the sum of the flows of all the active MFC's. On the other hand, the pressure test measurements show the pressure for only one MFC, not the sum as it is assumed that gas pressure is the same for all MFC's.

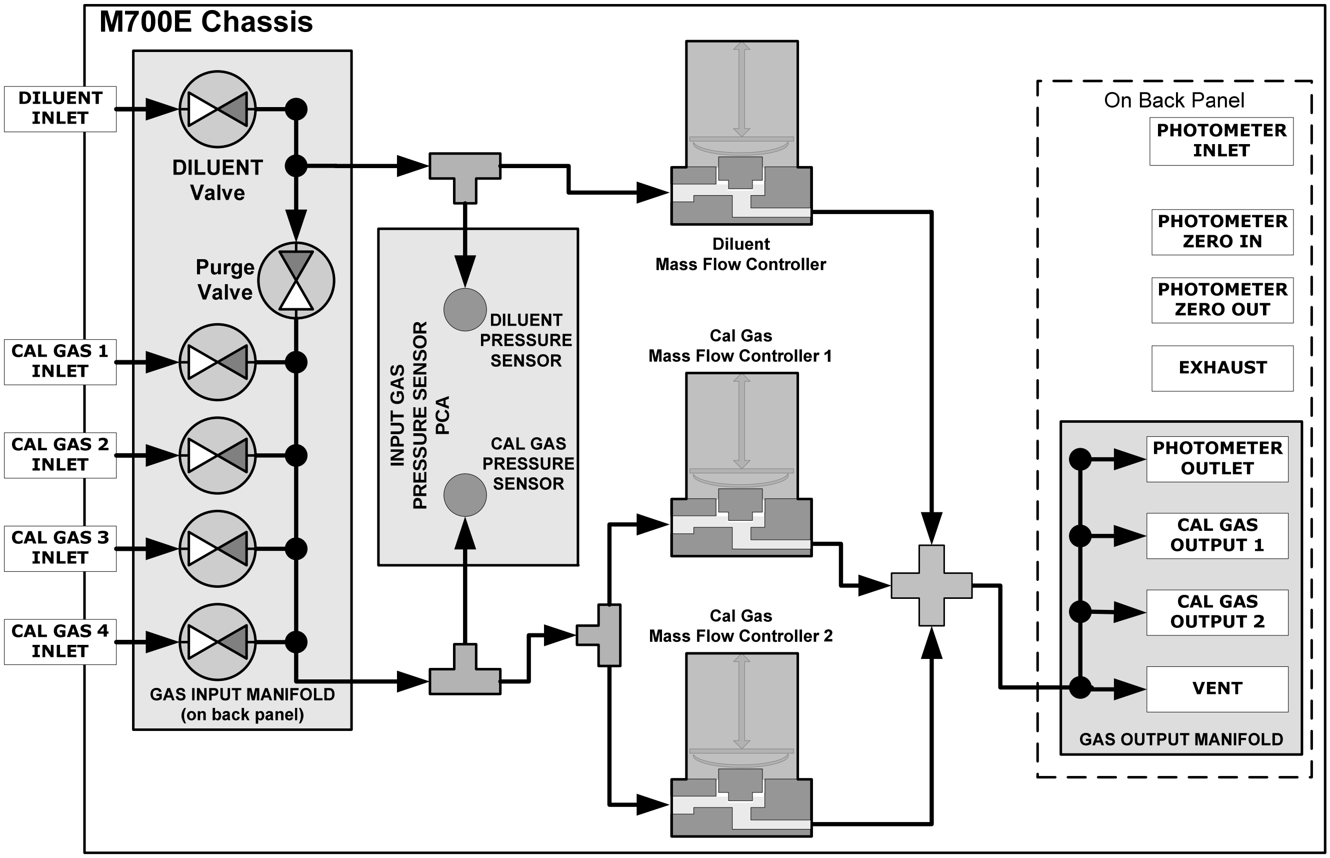


Figure 10-3: Basic M700E with Multiple Calibration Gas MFC's

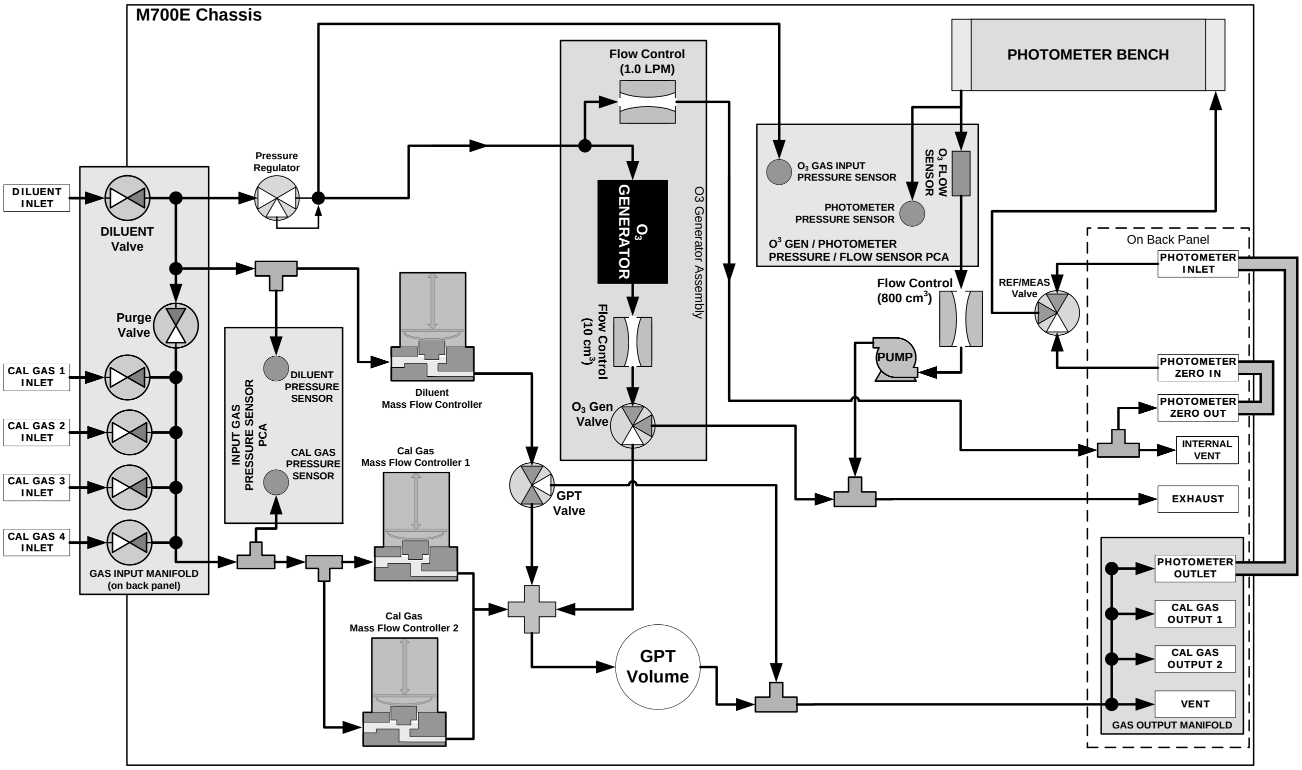


Figure 10-4: M700E with Multiple Calibration Gas MFC's and O_3 0ptions Installed

10.3 M700EU

10.3.1 M700EU

The M700EU allows the user to perform low-level GPT calibrations for NO_2 converter efficiency checks. The M700EU is a modified version of the M700E calibrator equipped with a special ozone generator capable of producing stable ozone concentrations for GPT (Gas Phase Titration) calibrations at much lower levels than the standard M700E.

The EU configuration adds an additional valve and flow controller on the ozone generators gas stream (see Figures 10-5). The additional valve and flow control provide increased control over the gas flow through the ozone generator. This increase in flow control allows for the production of much lower concentration of ozone, more precisely.

Table 10-3: M700EU Specifications.

Minimum GPT O_3 output	20 PPB LPM*
Maximum GPT O_3 output	6000 PPB LPM*
Minimum GPT O_3 concentration (at any flow rate)	3 PPB
Accuracy	+/- 10% (below 50 PPB), +/- 5 % (above 50 PPB) (with GPTPS)
Stability	Short Term, 1 hr: +/- 3% of reading
Precision	+/- 2% (with GPTPS).
*PPB LPM refers to the product of the total output flow and the ozone concentration. For example: 20 PPB LPM is equivalent to 20 PPB @ 1 LPM and 10 PPB @ 2 LPM etc.	

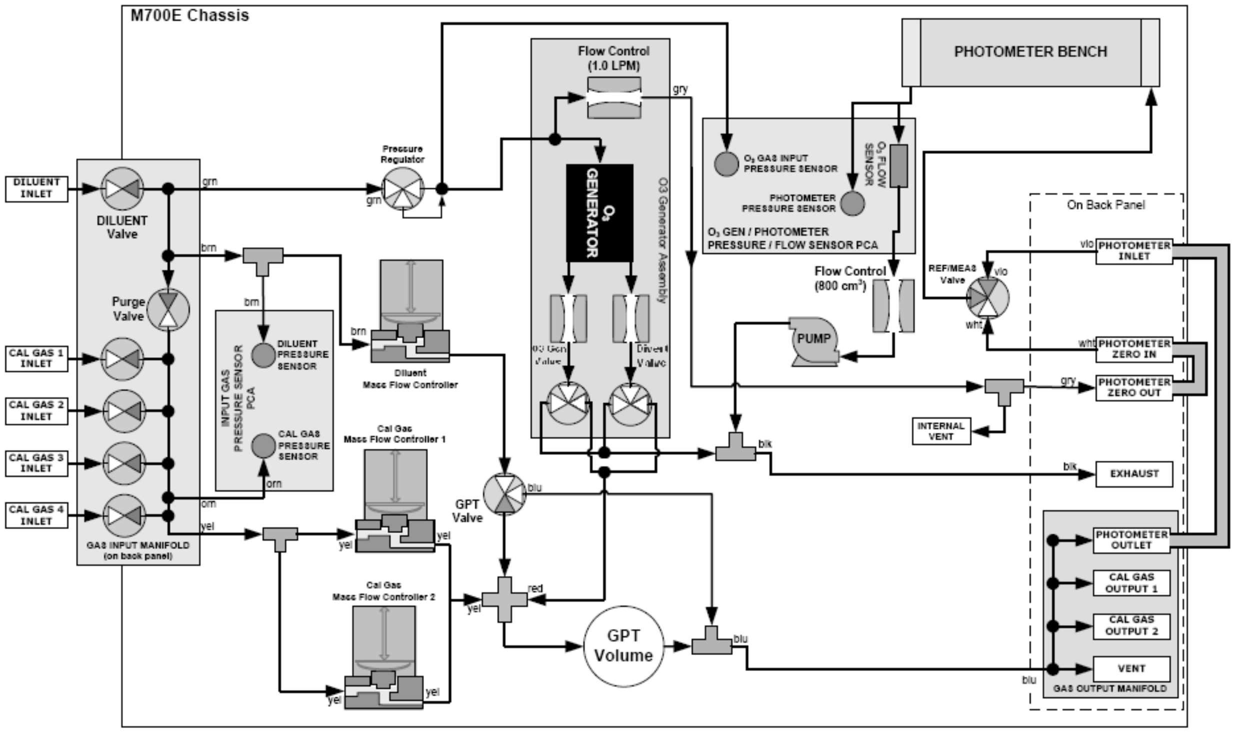


Figure 10-5: M700EU with Multiple Calibration Gas MFC's

Table 10-4: Operating Mode Valve States for M700EU calibrator and Photometer.

GAS TYPE	VALVES (E = Energized; D = De-energized)										MFC's			PHOTO PUMP
	CYL 1	CYL 2	CYL 3	CYL 4	PURGE	DILUENT	GPT	O_3 Gen	O_3 Div	PHOTO M/R	CAL1	CAL2[1]	DILUENT	
Generate Source Gas	E[2]	E[2]	E[2]	E[2]	D	E	D	D	D	D	ON[3]	ON[3]	ON	OFF
Generate O_3	D	D	D	D	D	E	D	E	E	Switching	OFF	OFF	ON	ON
GPT	E[2]	E[2]	E[2]	E[2]	D	E	E	E	E	D	ON[3]	ON[3]	ON	OFF
GPTPS	D	D	D	D	E	E	D	E	E	Switching	ON[3]	ON[3]	ON	ON
GPTZ	E[2]	E[2]	E[2]	E[2]	D	E	E	E	E	D	ON[3]	ON[3]	ON	OFF
PURGE	D	D	D	D	E	E	E	E	E	D	ON[3]	ON[3]	ON	ON
STANDBY	D	D	D	D	D	E	D	D	D	D	OFF	OFF	OFF	OFF

[1] Only present if multiple cal gas MFC option is installed.
[2] The valve associated with the cylinder containing the chosen source gas is open.
[3] In instrument with multiple MFC's the CPU chooses which MFC to use depending on the target gas flow requested.

It is recommended that a GPTPS (Gas Phase Titration Pre-Set) be performed prior to running the GPT as this allows the ozone generator to ramp up to the required ozone production and then to stabalize.

To insure the stability of the GPT concentration, each concentration point should be allowed a run time of at least 30 minutes.

Once you have established the target concentration, you will need to determine flow rates. As flows are very critical to the accuracy of such low levels, flow requirements should be established before attempting a GPT. The ozone generators regulator should be preset at approximatly 8PSI compared to the normal setting which is generally approximatly 20PSI.

The following requirements need to be used to determine the total flow.

1. The number of instruments and flow rate requirements of each analyzer, sampling from the calibrator even if the instrument is not involved in the test. The minimum flow rate should be the sum of all the instrument demand flows plus 10% (minimum excess).

2. The O_3 concentration and output flow must be chosen to keep the O_3 production above the minimum specification of 20 PPB LPM. The minimum flow rate (F_T) should be calculated using the following formula:

$$F_T \geq 20\text{ppb}\bullet\text{LPM} / O_3 \text{ Conc}$$

3. The NO flow rate should be greater than 45 cc/min, therefore larger dilution flows may be necessary. To achieve these low levels of NO_2 It will be necessary to use an NO bottle with a concentration between 1 and 2 PPM.

An example of a typical test would as follows:

1. Connect 1 – 2 PPM bottle of NO to M700EU's cal gas port and configure the port in the software.
2. Connect the M200EU to output manifold of the M700EU.
3. Perform a zero cal on the M200EU. Note that the NOx channel in an M200EU can be very slow to stabilize so, a minimum stabilization time of 30 min on zero air before performing zero cal is recommended.
4. Perform a span cal on the M200EU at 25 PPB NO.
5. Change the "STABILITY" parameter variable in the VARS menu to NO_2.
6. Run the following test sequences:
    a. GPTPS: 5 PPB NO, 3 PPB O_3 at 8.0 LPM, DURATION 15.0min
    b. GENERATE ZERO: 8.0 LPM, DURATION 15.0min (OPTIONAL)
    c. GPT: 5 PPB NO, 3 PPB O_3 at 8.0 LPM, DURATION 40.0min
        i. Record the stable NO value.
        ii. Record NO_2 stability at the end of the run
    d. GPTZ 5 PPB NO, 3 PPB O_3 at 8.0 LPM, DURATION 40.0min
        i. Record the stable NO value.
7. Repeat all of the steps 1-6 for:
    10 PPB NO, 8 PPB O_3, 8 LPM
    25 PPB NO, 20 PPB O_3, 5 LPM

Training Manual

11. 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 11-1 shows the analyzer's front panel layout, followed by a close-up of the display screen in Figure 11-2, which is described in Table 11-1. 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

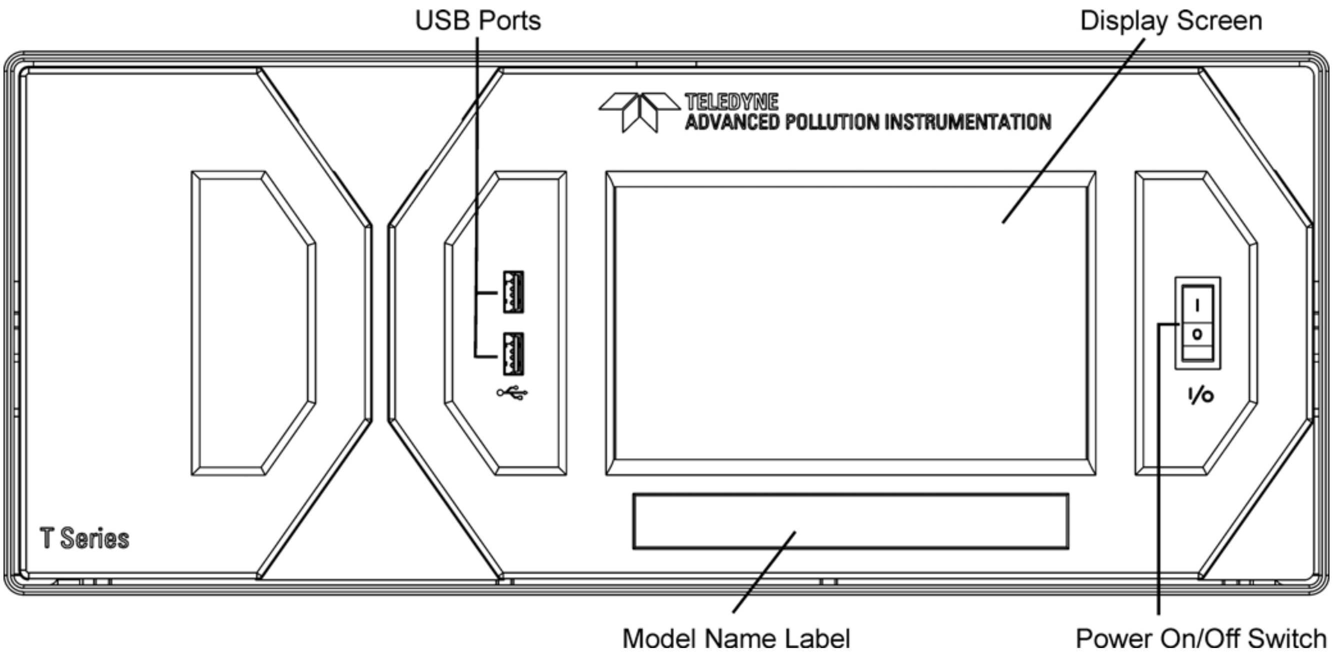


Figure 11-1: Front Panel Layout

Figure 11-2: 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 11-1 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 11-1: 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 On Blinking	Unit is not operating in sample mode, DAS is disabled. Sample Mode active; Front Panel Display being updated; DAS data being stored. Unit is operating in sample mode, front panel display being updated, DAS hold-off mode is ON, DAS disabled
	CAL	Yellow	Off On Blinking	Auto Cal disabled Auto Cal enabled Unit is in calibration mode
	FAULT	Red	Off Blinking	No warnings exist 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 11-3 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.

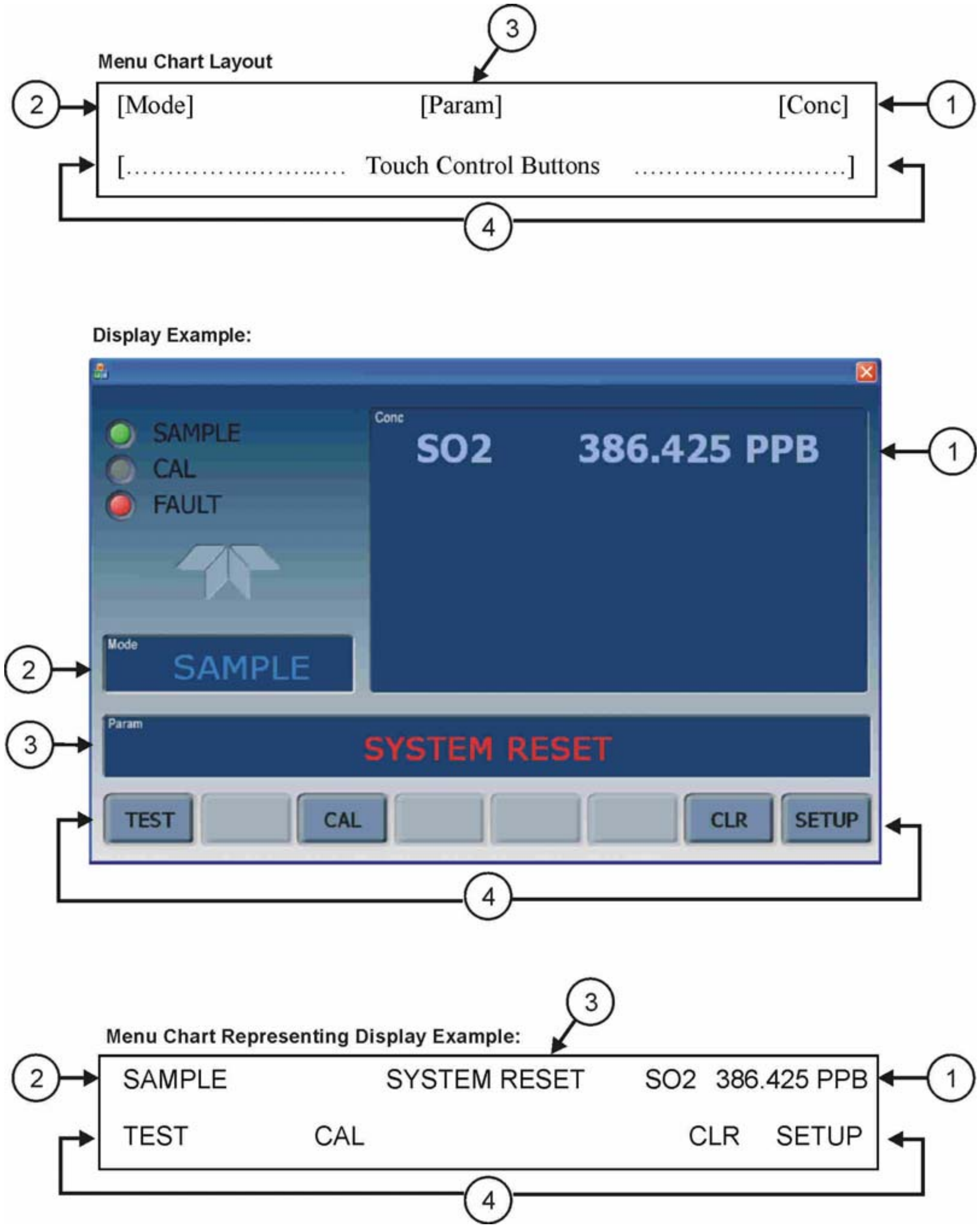


Figure 9-3: Display/Touch Control Screen Mapped to Menu Charts

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.

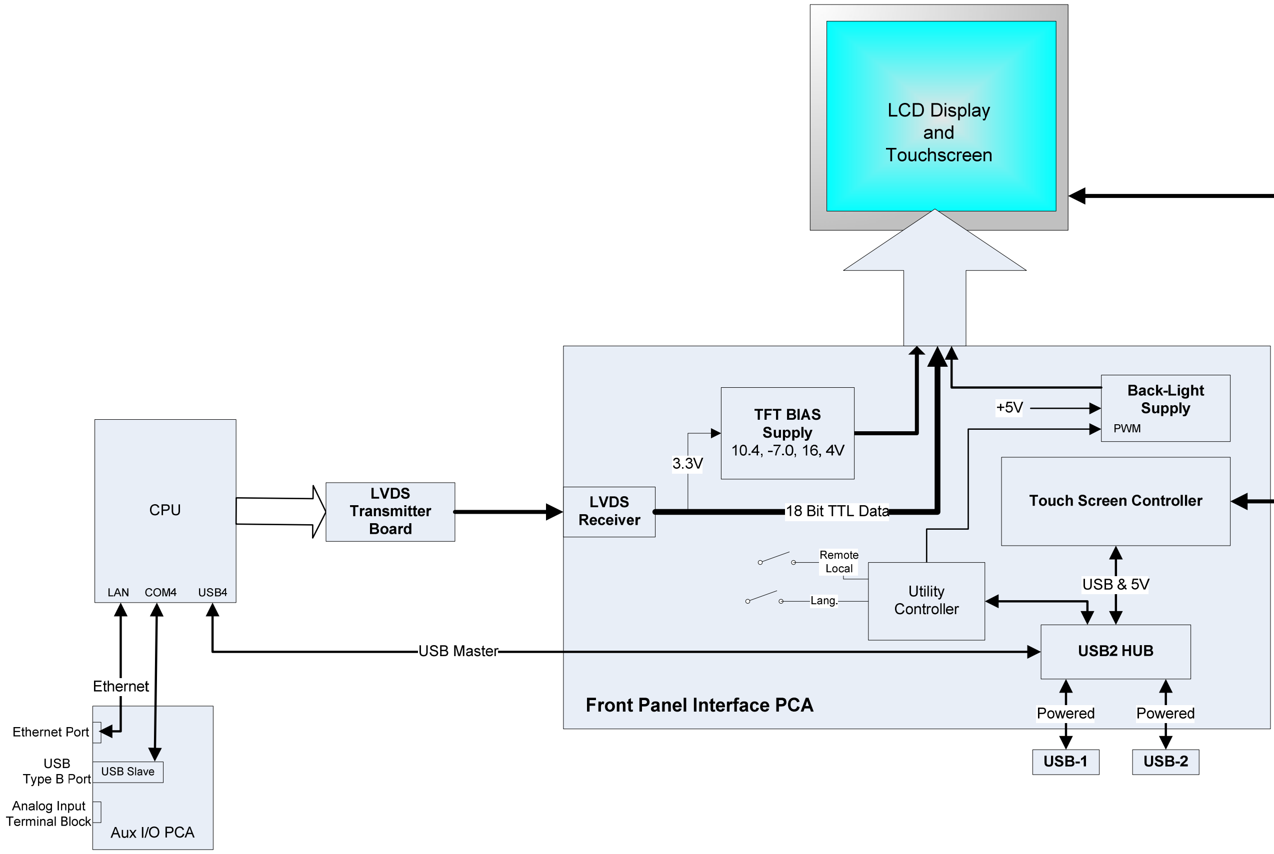


Figure 11-4: Front Panel and Display Interface Block Diagram

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

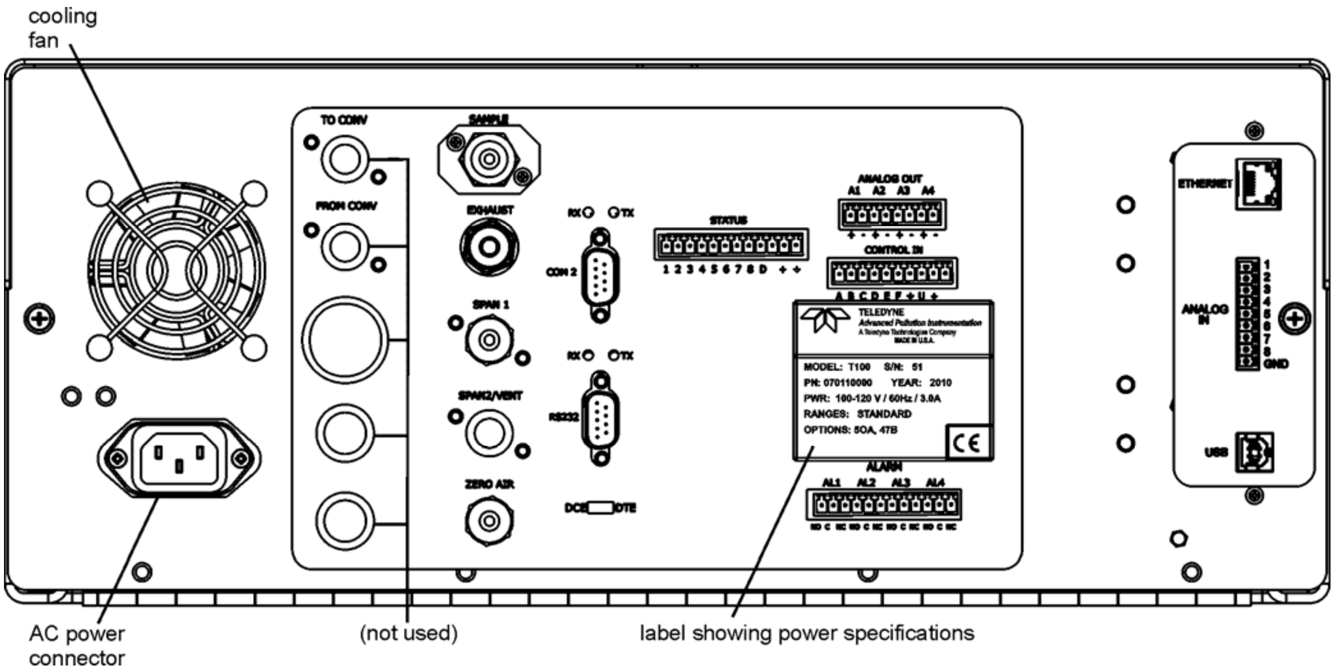


Figure 11-5: Rear Panel Layout

Table 11-2 provides a description of new components on the rear panel.

Table 11-2: 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.

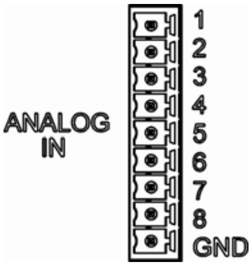


Figure 11-6: Analog In Connector

Pin assignments for the Analog In connector are presented in Table 11-3.

Table 11-3: 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 11-4: 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:

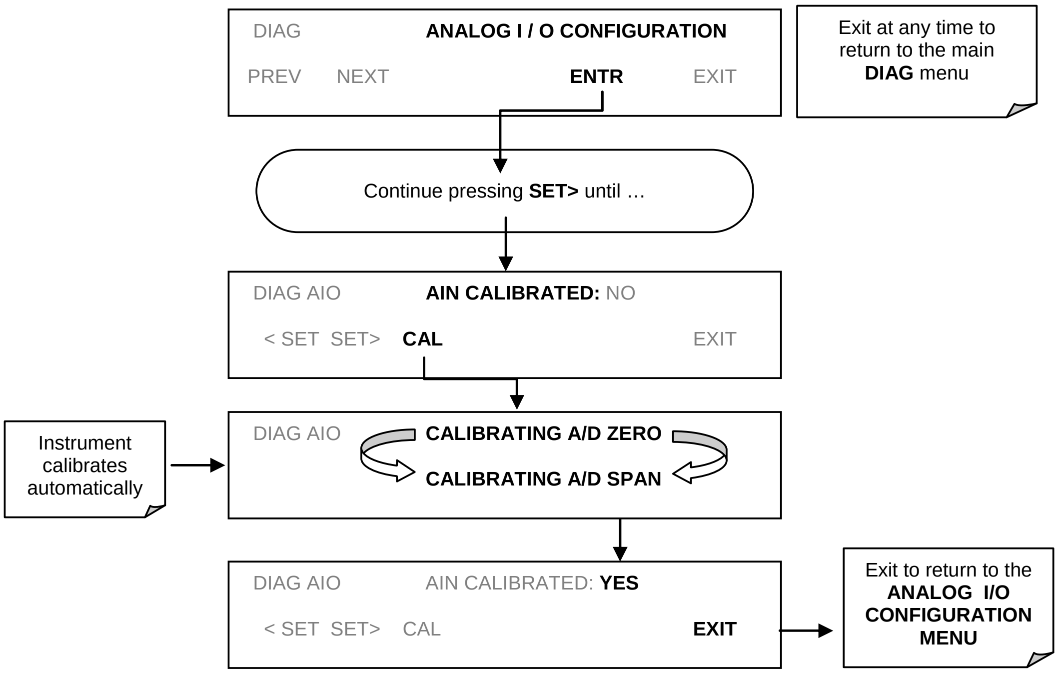


Figure 11-7: DIAG – Analog I/O Configuration – AIN Calibration

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:

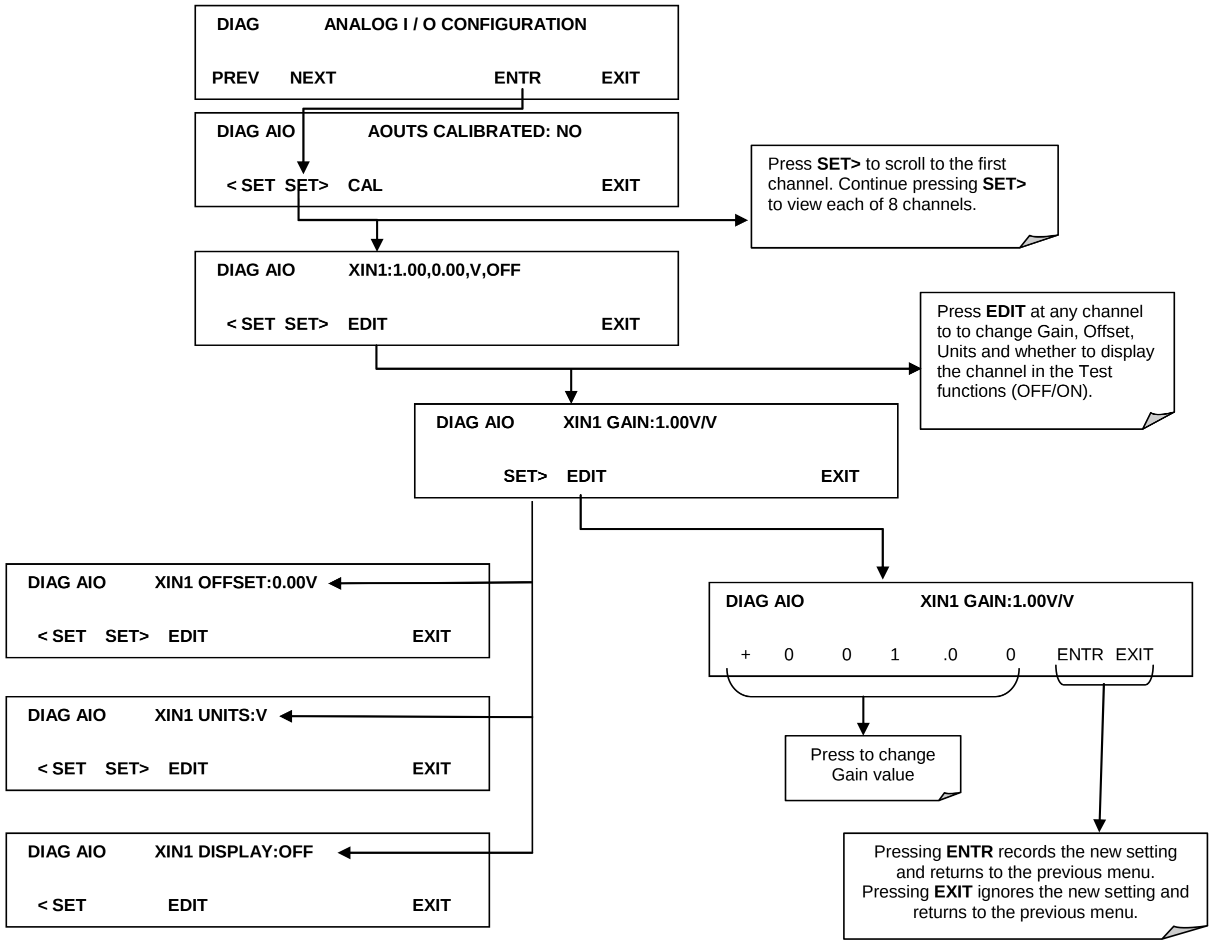


Figure 11-8 DIAG – Analog Inputs (Option) Configuration Menu

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

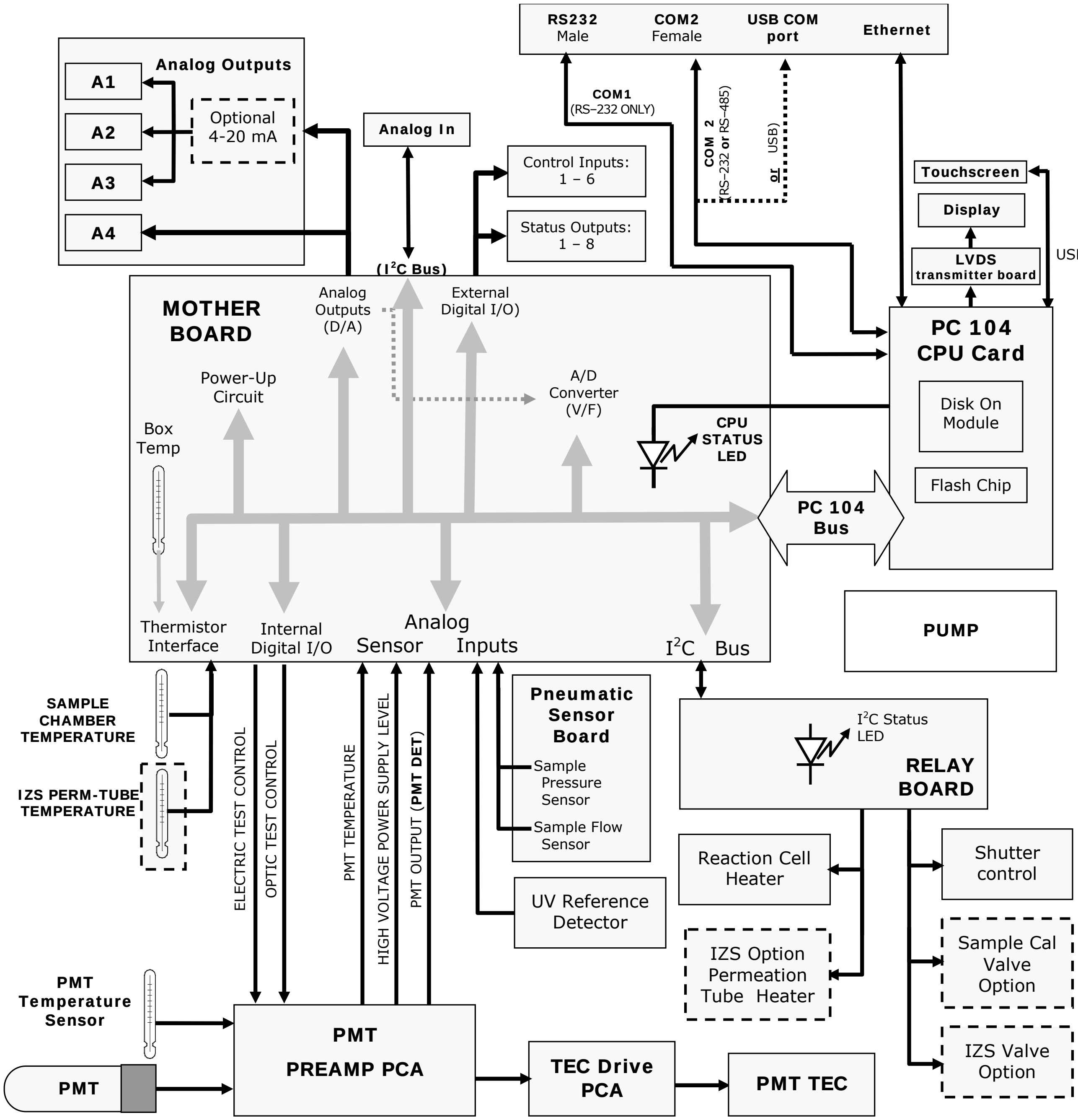


FIGURE 11-9, EXAMPLE OF AN ELECTRONIC BLOCK DIAGRAM (T100)

"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