INSTRUCTION MANUAL

MODEL 514
NDIR
ANALYZER

DANGER

HIGHLY TOXIC AND OR FLAMMABLE LIQUIDS OR GASES MAY BE PRESENT IN THIS MONITORING SYSTEM.

PERSONAL PROTECTIVE EQUIPMENT MAY BE REQUIRED WHEN SERVICING THIS SYSTEM.

HAZARDOUS VOLTAGES EXIST ON CERTAIN COMPONENTS INTERNALLY WHICH MAY PERSIST FOR A TIME EVEN AFTER THE POWER IS TURNED OFF AND DISCONNECTED.

ONLY AUTHORIZED PERSONNEL SHOULD CONDUCT MAINTENANCE AND/OR SERVICING. BEFORE CONDUCTING ANY MAINTENANCE OR SERVICING CONSULT WITH AUTHORIZED SUPERVISOR/ MANAGER.

P/N M63700
08/06/99
ECO # 99-0323

Teledyne Analytical Instruments
A Business Unit of Teledyne Electronic Technologies

Warranty

This equipment is sold subject to the mutual agreement that it is warranted by us free from defects of material and of construction, and that our liability shall be limited to replacing or repairing at our factory (without charge, except for transportation), or at customer plant at our option, any material or construction in which defects become apparent within one year from the date of sale, except in cases where quotations or acknowledgements provide for a shorter period. Components manufactured by others bear the warranty of their manufacturer. This warranty does not cover defects caused by wear, accident, misuse, or neglect. We assume no liability for direct or indirect damages of any kind and the purchaser by the acceptance of the equipment will assume all liability for any damage which may result from its use or misuse.

We reserve the right to employ any suitable material in the manufacture of our apparatus, and to make any alterations in the dimensions, shape or weight of any parts, in so far as such alterations do not adversely affect our warranty.

Important Notice

This instrument is intended to be used a tool to gather valuable data. The information provided by the instrument may assist the user in eliminating potential hazards caused by the process that the instrument is intended to monitor; however, **it is essential that all personnel involved in the use of the instrument or its interface with the process being measured be properly trained in the process itself, as well as all instrumentation related to it.**

The safety of personnel is ultimately the responsibility of those who control process conditions. While this instrument may be able to provide early warning of imminent danger, it has no control over process conditions, and can be misused. In particular, any alarm or control system installed must be tested and understood, both as they operate and as they can be defeated. Any safeguards required such as locks, labels, or redundancy must be provided by the user or specifically requested of Teledyne.

The purchaser must be aware of the hazardous conditions inherent in the process(es) he uses. He is responsible for training his personnel, for providing hazard warning methods and instrumentation per the appropriate standards, and for ensuring that hazard warning devices and instrumentation are maintained and operated properly.

TAI, the manufacturer of this instrument, cannot accept responsibility for conditions beyond its knowledge and control. **No statement expressed or implied by this document or any information disseminated by the manufacturer or his agents is to be construed as a warranty of adequate safety control under the user's process conditions.**

Table of Contents

1.0 Introduction
1.1 Method of Analysis 1-1
1.2 Modules (Condulets) 1-2
1.2.1 Source Module 1-5
1.2.2 Sample Module 1-5
1.2.3 Power Module 1-5
1.2.4 Detector Module 1-5
1.2.5 Local Meter Readout 1-6
1.2.6 Control Module 1-6
1.3 Typical Applications 1-6

2.0 Operational Theory
2.1 Circuit Description 2-2
2.1.1 Source Module 2-2
2.1.2 Sample Module 2-3
2.1.3 Power Module 2-4
2.1.4 Detector Module 2-8
2.1.5 Control Module 2-10

3.0 Installation
3.1 Location 3-1
3.2 Sample Saction Installation 3-1
3.2.1 Filtering 3-1
3.2.2 Effluent Return 3-2
3.2.3 Flow Control 3-2
3.2.4 Selector Manifold 3-3
3.2.5 Automatic Zero Operation 3-3
3.3 Electrical Installation 3-3
3.3.1 Power Check 3-3
3.4 Analysis Unit 3-5
3.5 Optical Alignement 3-6

4.0 Operations
4.1 Control Functions 4-1
4.1.1 General Purpose Version: Analysis Section 4-1
4.1.2 General Purpose Version: Controle Module 4-2
4.1.3 Explosion-Proof Version: Control Module 4-3

4.2 Start-up 4-4
4.2.1 Preliminary Inspection 4-4
4.2.2 Pre-Start-up Electrical Checkout 4-5
4.2.3 Power On Observation 4-5
4.3 Calibration 4-6

5.0 Maintenance & Troubleshooting
5.1 Replacement of Sample Cell Optics 5-2
5.2 Replacement of Filter Wheel Optics 5-2
5.3 Replacement of Source Lamp Assembly 5-3
5.4 Replacement of Filter Position Sensor 5-4
5.5 Replacement of Preamplifier Circuitr Card 5-4
5.6 Re-screening of Lens 5-5
5.7 Troubleshooting 5-5

Appendix
Specifications A.1
Application Data A.2
Recommended Spare Parts List A.3
Drawing List A.4

1.0 Introduction

The Model 514 Photometric Analyzer measures the concentration of one component in a mixture of liquids or gases continuously by measuring the radiation absorbed in selected bands in the near infrared (NIR) spectral region. Most liquids or gases having a characteristic absorption spectrum in this region can be measured with the analyzer. When we refer to the NIR region we mean that portion of the electromagnetic energy spectrum from 1.0 to 2.8µ. This range can be extended to somewhat longer wavelengths using special detectors. Most organic and some inorganic compounds can be analyzed in the NIR region.

For example, the 514 is used to analyze parts per million (PPM) or the percentage concentration of water in a variety of compounds (see Typical Applications). The analyzer can also be used to measure the concentration of one organic compound in the presence of another organic compound.

1.1 Method of Analysis

The 514 contains an optical system consisting of a quartz iodine source lamp for NIR energy emission, collimating lens, sample cell and detector. Isolator or light beam tubes filled with nitrogen gas interconnect the source and sample, and sample and detector modules. In front of the detector is a motor-driven filter wheel containing two optical interference-type filters, located 180° from each other. These filters, designated the reference and measuring filters, are alternately and continuously rotated in and out of the optical path. The sample flows continuously through the sample cell absorbing energy at various wavelengths throughout the NIR spectrum. The wavelengths and intensities of absorption peaks throughout the spectrum are characteristic of the specific compounds that are present in the sample.

In any photometric analysis, there is always the component that we are interested in analyzing, and background components that we are not interested in measuring. Both the component of interest and the background component may have complex NIR absorption spectra.

The quantitative measurement of a compound using the 514 is based on Beer's Law, which states that the intensity of a beam of monochromatic radiation transmitted through a sample decreases exponentially as the concentration of the absorbing sample increases.

To approximate monochromatic radiation, a specific wavelength is isolated by the use of the interference-type filters. The filters allow transmission of NIR over a narrow band pass region of the NIR spectra and completely block all other wavelengths. Proper selection of the measuring and reference filter wavelengths allows the accurate isolation and measurement of the component of interest.

The use of two filters allows cancellation of energy changes due to turbidity, dirty sample cell windows, and aging of the source and electronic components.

The center band pass of the measuring filter is selected to transmit energy in a narrow region where the component of interest absorbs strongly in comparison with background absorbance. The center band pass of the reference filter is selected to transmit energy in a band pass region where the background absorption of NIR energy is equivalent to that seen by the measuring filter. The reference filter is also selected to be in a region where the component of interest has minimal absorption of energy.

The optical beam is converted from steady state to pulsed energy by the rotation of the filters in the optical path. The measuring and reference pulses of radiation strike a detector which converts the pulses of radiation into electrical pulses which are then amplified. Signal processing involves converting the electrical signals to logarithmic signals, and then comparing the measuring to the reference logarithmic signals in order to give a readout representing the concentration of the component of interest in the sample.

1.2 Modules (Condulets)

Physical layout of the analyzer is shown in Figures 1-1 and 1-2. The control module is usually located apart from the analysis unit in a control room. The explosion-proof version has the control and analysis units mounted in one weather-resistant NEMA-12 enclosure suitable for outdoor installation.

The analysis section is designed for hazardous area installation. Housings are rated for use in Class I, Div. I, Group D hazardous environments.

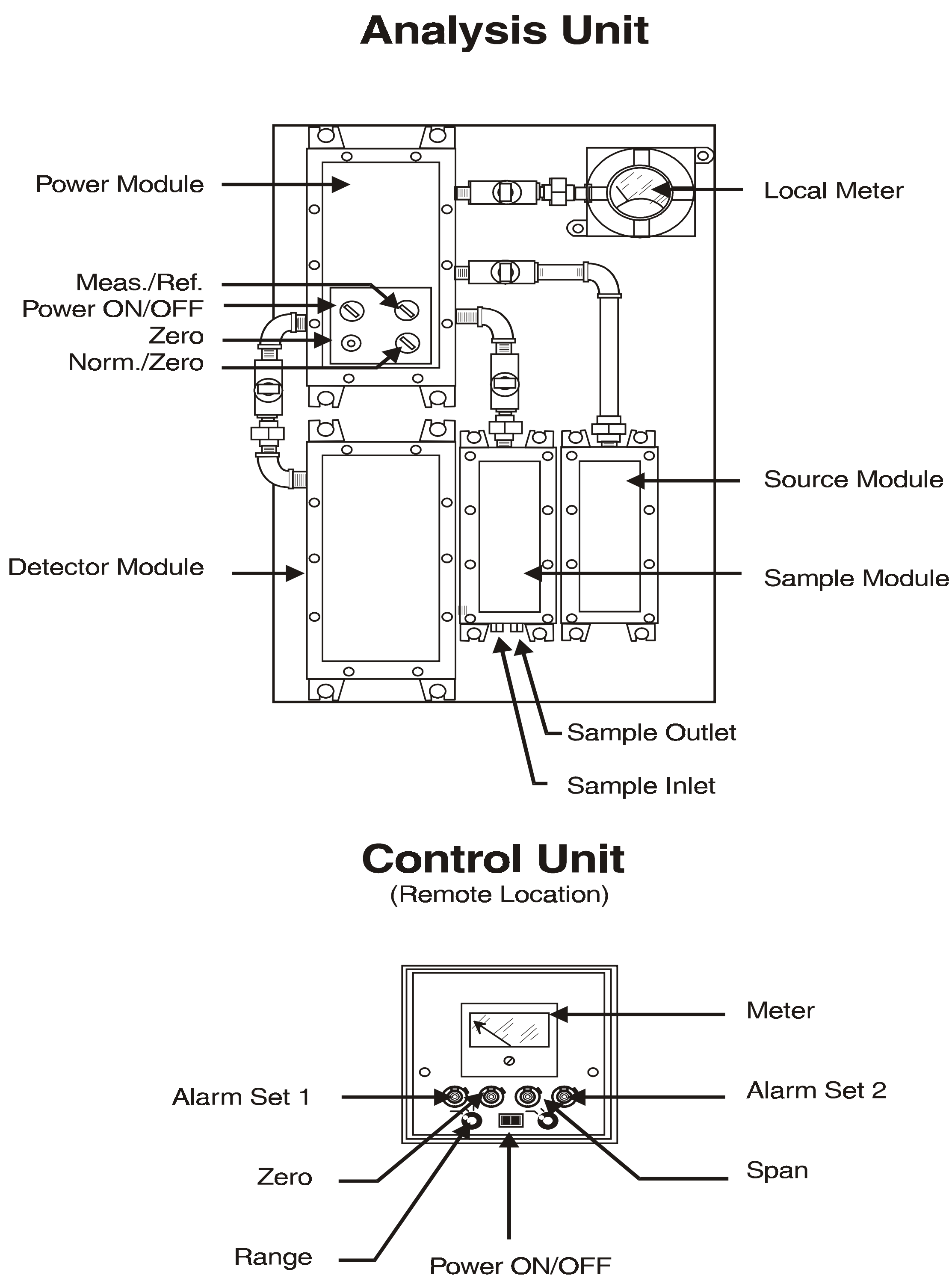


Figure 1-1. Model 514 Photometric Analyzer (with General-Purpose Control Unit)

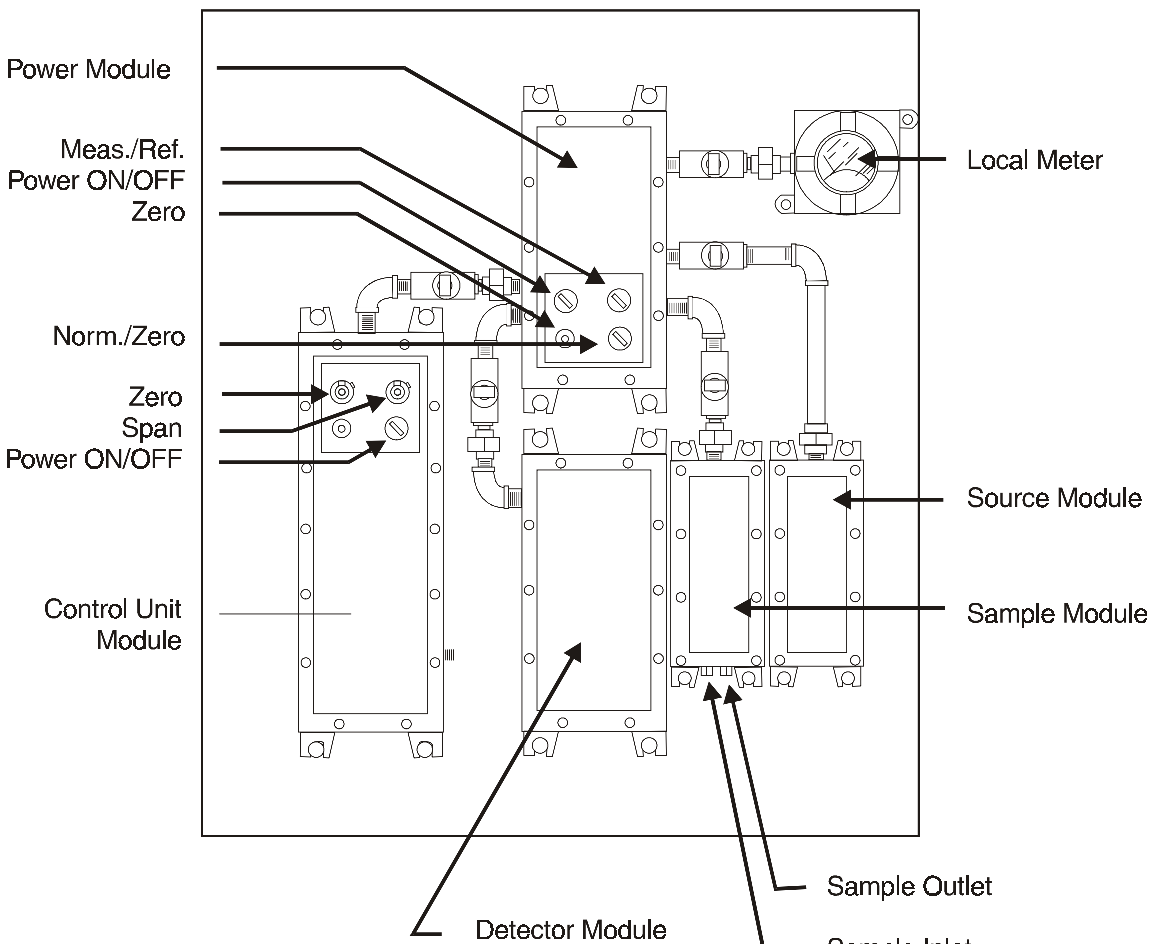


Figure 1-2. Model 514 Photometric Analyzer (with Explosion-Proof Control Unit)

1.2.1 Source Module

The source module or condulet houses the quartz iodine source lamp, collimating lens/lens holder, and transformer. The 115 VAC power to the source transformer is derived directly from the line voltage regulating transformer installed in the power module.

1.2.2 Sample Module

The insulated sample module has sample inlet and outlet lines constructed of 1/8" O.D. 316SS tubing. The sample is routed through a preheater, through the sample cell, then drained from the outlet port. A thermistor-controlled preheater and compartment space heater are powered from temperature controllers located in the power module. A thermal cutout switch prevents temperature “runaway”.

The sample cell, which is configured for each particular application, is provided with sapphire windows to admit NIR radiation.

1.2.3 Power Module

The power module contains a line voltage regulating transformer (with capacitor) and three temperature controller circuit cards.

Each of the controllers incorporates a bridge circuit containing a thermistor located in the volume/compartment to be controlled. Bridge imbalance produces an error signal, resulting in operation of the final control element (heater) to restore bridge balance, and controlling the temperature to within a fairly narrow proportional band.

Control functions for the analysis section are located on the power module (see Figure 4-1).

1.2.4 Detector Module

As noted above, the detector is a part of the optical system (see Figure 2-1). The detector cell is mounted within a hermetically sealed block with a quartz window through which the optical energy enters. The assembled cell block, together with the preamplifier subassembly, filter wheel, and filter position sensor, are contained within a temperature-controlled compartment

In addition to the heated optical compartment, the detector module contains the chopper motor, power transformer, and six circuit cards whose function is described in section 2. 2. 4, Detector Module.

1.2.5 Local Meter Readout

For analyzer configurations having a remotely located control module, the local meter is used to read the reference and measuring peak heights, or the voltage output from the buffer amplifier before voltage-to-current conversion.

When the control module is integral with the analysis section, i. e., the explosion-proof configuration, the meter is connected to the output of the control module in order to display the concentration of the component of interest as well as the previously mentioned information.

1.2.6 Control Module

In the explosion-proof version, the calibration meter is used as an all purpose readout; in this case, there is some modification in the switching at both the control module and power module.

In addition to control switching, adjustment (zero and span), and readout components, the control module has provisions for five circuit cards: an automatic zero/extended voltage amplifier, E-to-I converter, I-to-E converter, power supply, and alarm comparator. The alarm comparator circuit card incorporates two circuits with jumpers that permit setting the alarm(s) for high, low, high/low, high/high, and low/low settings. Setpoint adjustments are performed with potentiometers on the module front panel.

1.3 Typical Applications

WATER MONITORING

Background	**Typical Range**
Acids, including:	0–4000 PPM
Acetic	
Formic	
Sulfuric	
Acetaldehyde	0–1000 PPM
Air	0–2%
Alcohols, including:	0–400 ppm
Butanol	
Ethanol	
Isopropanol	
Methanol	
Alkanes, including:	0–500 ppm
Heptane	
Hexane	

Ammonia	0–1000 ppm
Aromatics, including:	0–500 ppm
Benzene	
Cumene	
Toluene	
Xylene	
Chlorinated Hydrocarbons including:	0–200 ppm
Carbon Tetrachloride	
Ethyl Chloride	
Ethylene Dichloride	
Methyl Chloride	
Perchloroethylene	
Propylene Dichloride	
Trichloroethylene	
Vinyl Chloride	
Chloroprene	0–200 ppm
Chloropicrin	0–200 ppm
Deuterium Oxide	0–200 ppm
Epichlorohydrin	0–2000 ppm
Ethylene Glycol	0–500 ppm
Freons	0–500 ppm
Gasoline	0–500 ppm
Hydrogen Fluoride	0–10%
Hydroperoxides	0–5%
Kerosene	0–500 ppm
Ketones	0–1000 ppm
Methyl Acetate	0–1000 ppm
Methyl Methacrylate	0–1000 ppm
Oils	0–1%
Olefins	0–500 ppm
Pentane	0–300 ppm
α-Picolene	0–300 ppm
Phenol	0–1000 ppm
Polyols	0–500 ppm
Propylene Glycol	0–500 ppm
Propylene Oxide	0–200 ppm
Sulfinol	0–15%
Sulfur Dioxide	0–1000 ppm
Vinyl Acetate	0–2%

NOTE: Range may be higher or lower per application.

OTHER NIR ABSORBERS

Acetic Acid
Alcohols
Amines
Aromatics
Butadiene
Carbonyls
Chloroprene
Esters
Hydrocarbons
Hydrogen Chloride
Hydrogen Fluoride
Hydroxyl Value
Ketones
Olefins
Oximes
Epoxides
Methylene

2.0 Operational Theory

The energy source for the analyzer is provided by a high intensity quartz iodine lamp located in the source module. Quartz iodine was chosen because it produces sufficient NIR to operate the system and maintains a nearly constant brightness over its lifetime. (See Figures 2-1 and 2-2).

This energy is then fed through the sample, which is temperature controlled, and into the detector module where it passes through a rotating filter wheel before reaching the lead sulfide (PbS) detector.

The filter wheel, driven at 30 RPS or 1800 RPM by a synchronous AC motor, contains two optical filters with bandpasses selected for each application, thus providing reference and measuring pulses from which the required information may be obtained.

The detector receives pulses at the rate of 60 PPS, or two pulses per revolution of the filter wheel. Every other pulse is from the measuring filter, while the alternate pulse is from the reference filter, so that pulses through the measuring filter alternate with pulses through the reference filter. A filter position sensor, which is an optical device having an integral light source and light detector, differentiates between the two.

The two entrained pulses received by the detector each revolution are amplified through a preamplifier which is physically located inside the sealed compartment with the filter wheel and detector. This signal is then sent to a clamping circuit where an exact zero reference is established.

This clamped video signal is then fed through a gain control network, which is controlled by the automatic gain control loop, through another amplifier, to the electronic switch. This switch is controlled by the switch driver network which derives its information from the filter position sensor in order to separate the entrained video signal into its component parts of a measuring peak and a reference peak. These peaks are then fed through a balancing network and channeled into separate peak height detectors which produce DC voltage levels which are exactly equal to the peak height or absolute magnitude of the voltage from the base to the peak of each of the pulses.

At this point the reference signal is fed back to the automatic gain control loop to maintain the desired system gain. In addition, both the measuring and reference levels are fed to selector switches in order to enable direct meter indication, which greatly eases the task of balancing the system during initial system installation and periods of calibration.

The DC voltage levels are fed to a logarithmic ratio amplifier which produces a voltage output that is proportional to the logarithm of the ratio of the two DC input voltages. This output voltage, directly proportional to the concentration of sample, is, within certain limits, a linear function of the concentration. For purposes of transmission, the voltage signal is converted by an E-to-I converter; thus, the output signal from the analysis unit is a current signal that is proportional to the concentration of sample in the sample module.

Upon arrival at the control module, which is normally located in a remote location away from the analyzer unit, the signal is processed through an I-to-E converter which incorporates fine zero and span controls for calibration. Following the span control, a buffer amplifier provides isolation between the calibrated signal and any of the selected output devices. This signal is then sent to the meter driver circuit and readout meter, to the alarm comparator circuits, voltage output circuits, current output circuits, etc., depending upon the particular application requirement.

There is also an option of providing an automatic zero circuit (see drawing B-14729) in the control unit. This circuit provides electrical signals for switching a fluid which contains none of the material to be measured into the sample module, electrically adjusting the zeros and switching back to sample.

2.1 Circuit Descriptions

2.1.1 Source Module

The source module is the source of infrared energy. This is provided through the use of a high-intensity quartz iodine lamp operating directly from a 6.3 V transformer. To ensure a stable source of radiation in the face of line-voltage variations, the lamp transformer derives its input directly from a line voltage-regulating transformer, selected for its ability to maintain a constant output voltage level regardless of fluctuations in the input line voltage within the control range of 105 to 130 VAC.

In some applications where we have an abundance of energy due to low sample absorption, the focusing lens is removed to avoid excess energy reaching the detector. However, other systems have high energy losses in the sample module due to strong sample absorbance or exceptionally long sample path-lengths. These systems require a focusing lens to gather and collimate the radiation for maximum utilization of source energy. The collimating lens is quartz.

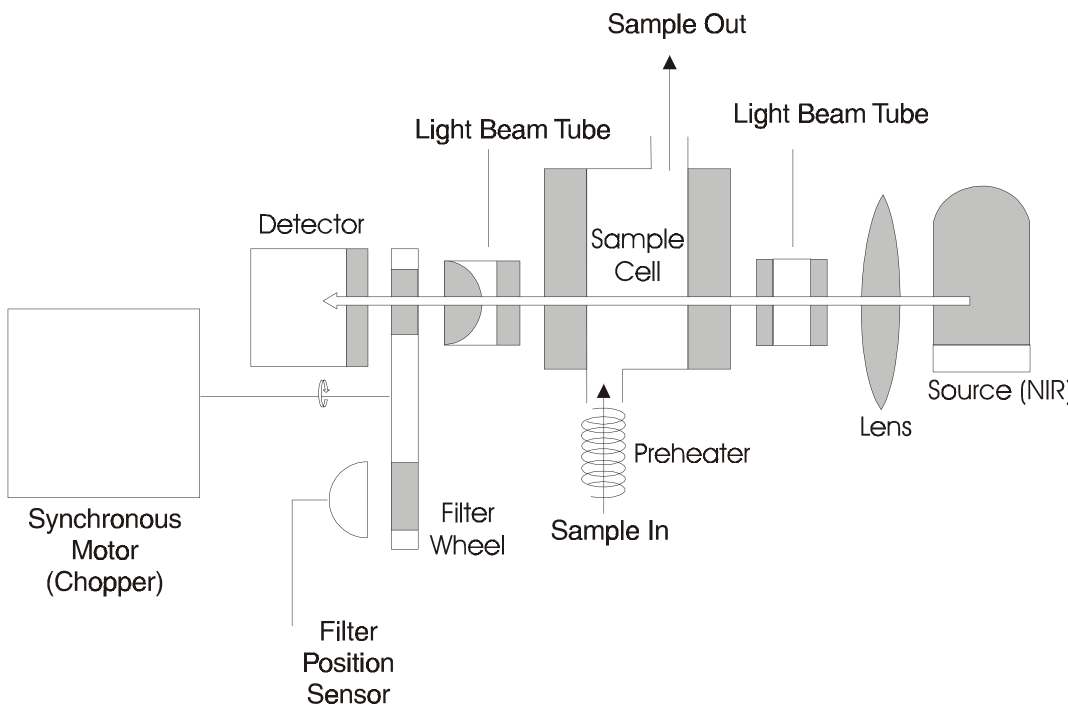


Figure 2-1. Optical System

2.1.2 Sample Module

The sample cell, generally constructed of 316SS, is located in the path of the NIR radiation, between the source and the detector modules. Each compound in the sample path exhibits its own characteristic absorption spectrum. Cell spacer thicknesses will vary depending upon the absorbance of the component of interest at the measuring wavelength. Due to the possible variation of absorption with temperature, it is necessary to maintain the sample at a constant temperature during analysis. To achieve this, two separate methods of temperature control are employed

1. A preheater is used on the incoming sample stream to raise it to the desired level.
2. The entire sample module is separately controlled to maintain the sample temperature during analysis.

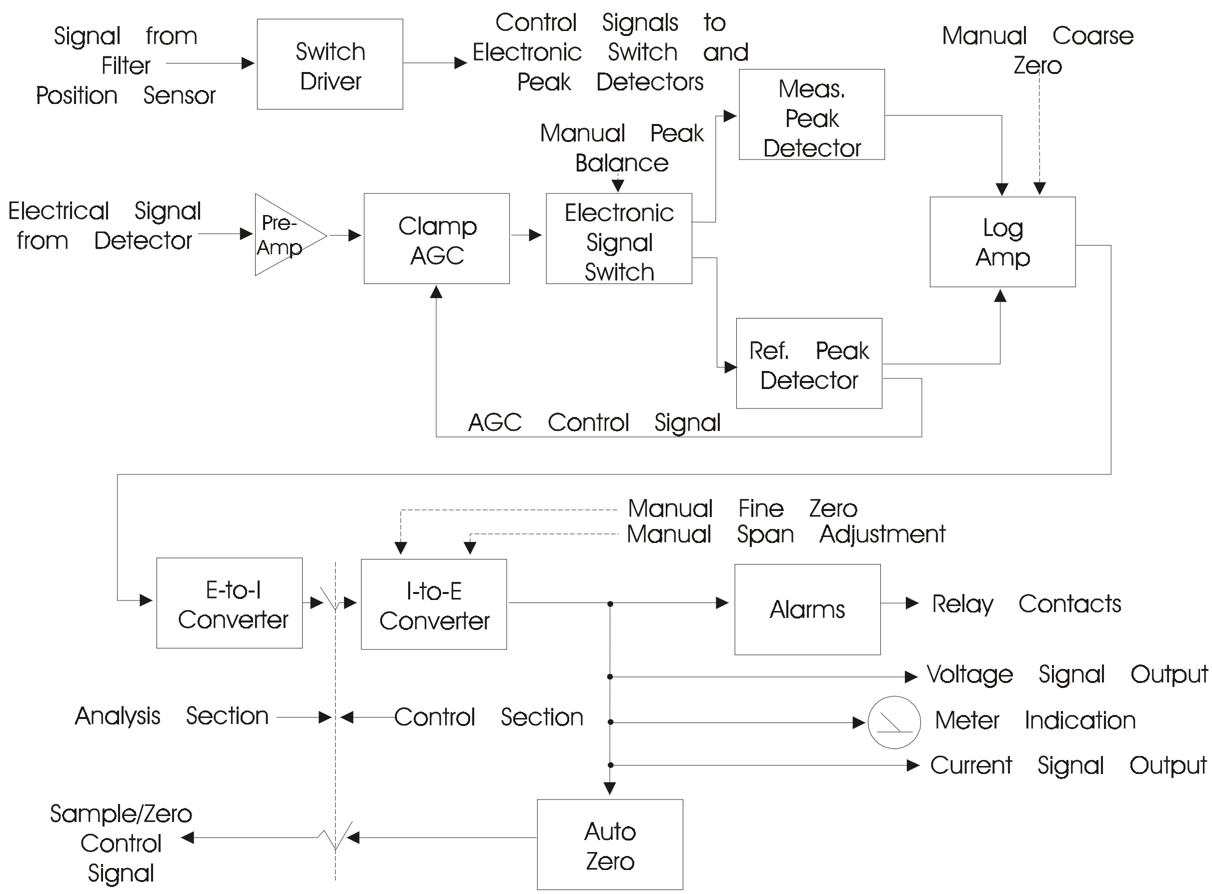


Figure 2-2 Analyzer System - Block Diagram

2.1.3 Power Module

See Figure 2-3. The power module controls power to the analyzer unit, providing the switching function for the local meter, and providing temperature control for the sample and detector modules. In the case of the explosion-proof configuration, where the control unit is mounted locally, the power module simply routes the AC input power to its destination and allows the control unit to provide the ON/OFF function.

When power is applied to the system, it is directed to the constant voltage transformer and to the three temperature controllers which are insensitive to line voltage fluctuations.

In order to facilitate easier calibration and to provide a quick visual indication of the instrument’s status, a local meter is provided. With the

NORM/ZERO switch on the power module set to the NORM position, the meter will provide a constant readout of either the reference level or the measuring level. During calibration periods, the ZERO switch control may be used to monitor the signal into the E-to-I converter, and if a known zero sample is applied, then the ZERO potentiometer may be varied to ensure zero output to the control unit.

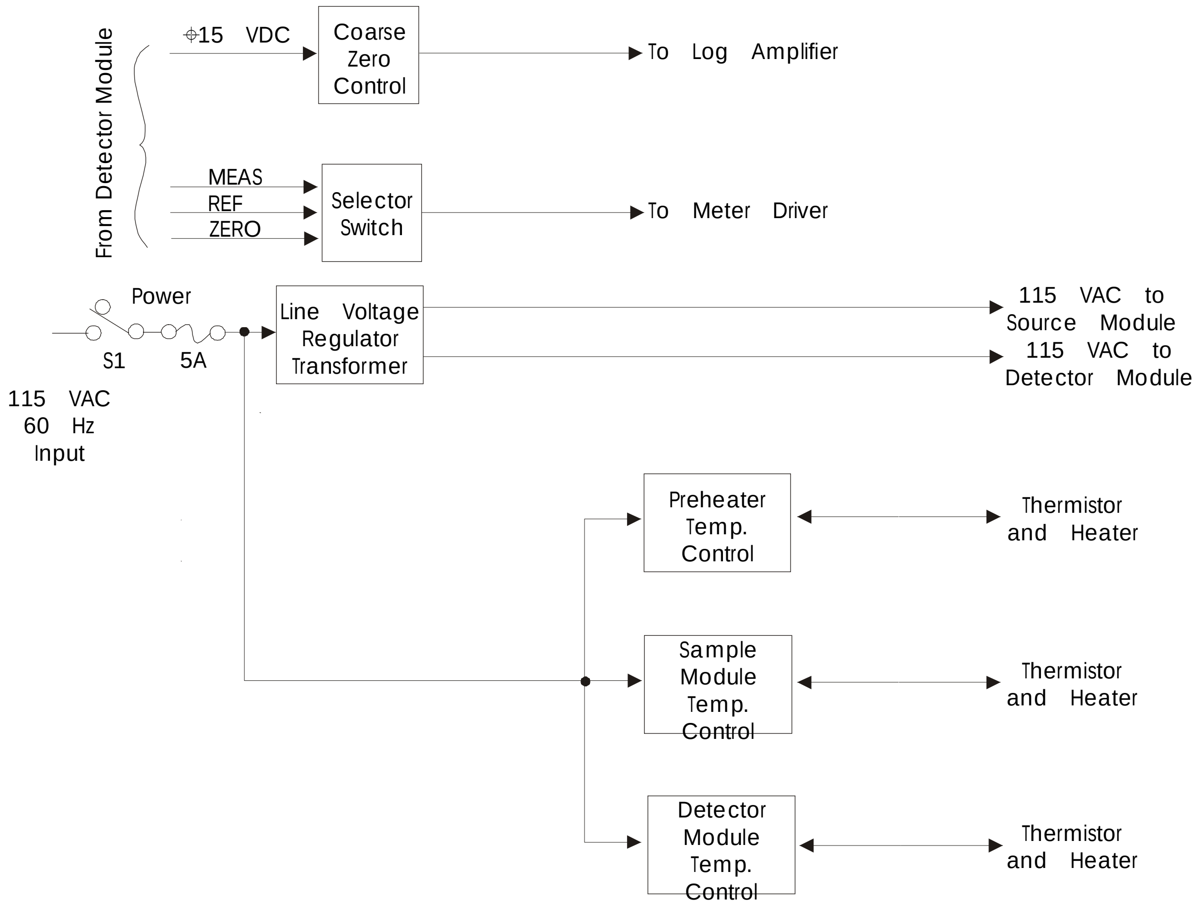


Figure 2-3. Power Module - Block Diagram

All of the temperature controller circuit cards for the analyzer are located in the power module. The schematic diagram for these circuits is shown in dwg. B-15016.

The purpose of the time-proportional temperature controllers is to sense the temperature in the compartment or volume to be controlled and, at a rate of approximately twice per second, turn on the heater(s) for a specified portion of the time cycle, depending upon how much heat is needed. When

ON, the heater is fully turned on; only the duration of the ON interval will vary.

As the compartment heats up, the heater-on time interval is shortened. The less heat needed, the shorter the heater-on interval during each cycle. Since TRIAC Q1 is used as the control element for the heater, it is supplied with the full AC line power. The output TRIAC is mounted on a heat sink and can handle the full heater wattage.

A4 is a zero crossing switch and TRIAC driver, providing a gating signal output pulse to turn on the TRIAC. Turn-on pulses are only applied to TRIAC Q1 when commanded by a control signal, i.e., at the time the line voltage crosses zero.

A1B is a comparator that compares the output of the temperature amplifier (voltage representing temperature) A1A (at pin 5) with a reference ramp voltage from A2B (at pin 6), causing TRIAC Q1 to be turned on for a time interval proportional to the required heat.

A2B and A3 comprise a ramp generator that produces a sawtooth voltage ranging from 6 to 12 VDC with a period of approximately one-half second.

The output voltage from the temperature amplifier A1A will range from less than 6 volts to something more than 12 volts. When the output voltage is greater than 12 volts, the TRIAC will be turned on a full time interval each cycle. When the output is less than 6 volts, the TRIAC will be turned off all the time. When the output is in the middle of the range (approximately 9 volts), the TRIAC will be turned on for about one-half of the time interval.

The thermistor, which is a negative temperature coefficient device, is set up in a bridge circuit. Resistor R2, the setpoint resistor, is selected to be approximately equal to the resistance of the thermistor at the desired operating temperature. The other half of the bridge, the voltage divider network comprised of resistors R4 and R5, is balanced. When the resistance of the thermistor is equal to the resistance of R2 at the desired operating temperature, the bridge is balanced and the voltage at pins 2 and 3 of A1A is the same.

When the temperature in the compartment rises, the thermistor resistance will decrease and the inverting input of A1A will fall below the reference point. This input will be amplified by A1B to broaden the proportional band and preclude the possibility of the device overshooting and operating as an on/off temperature controller.

Circuit components C1, D3, and D4 provide stable internal power to the rest of the controller circuitry.

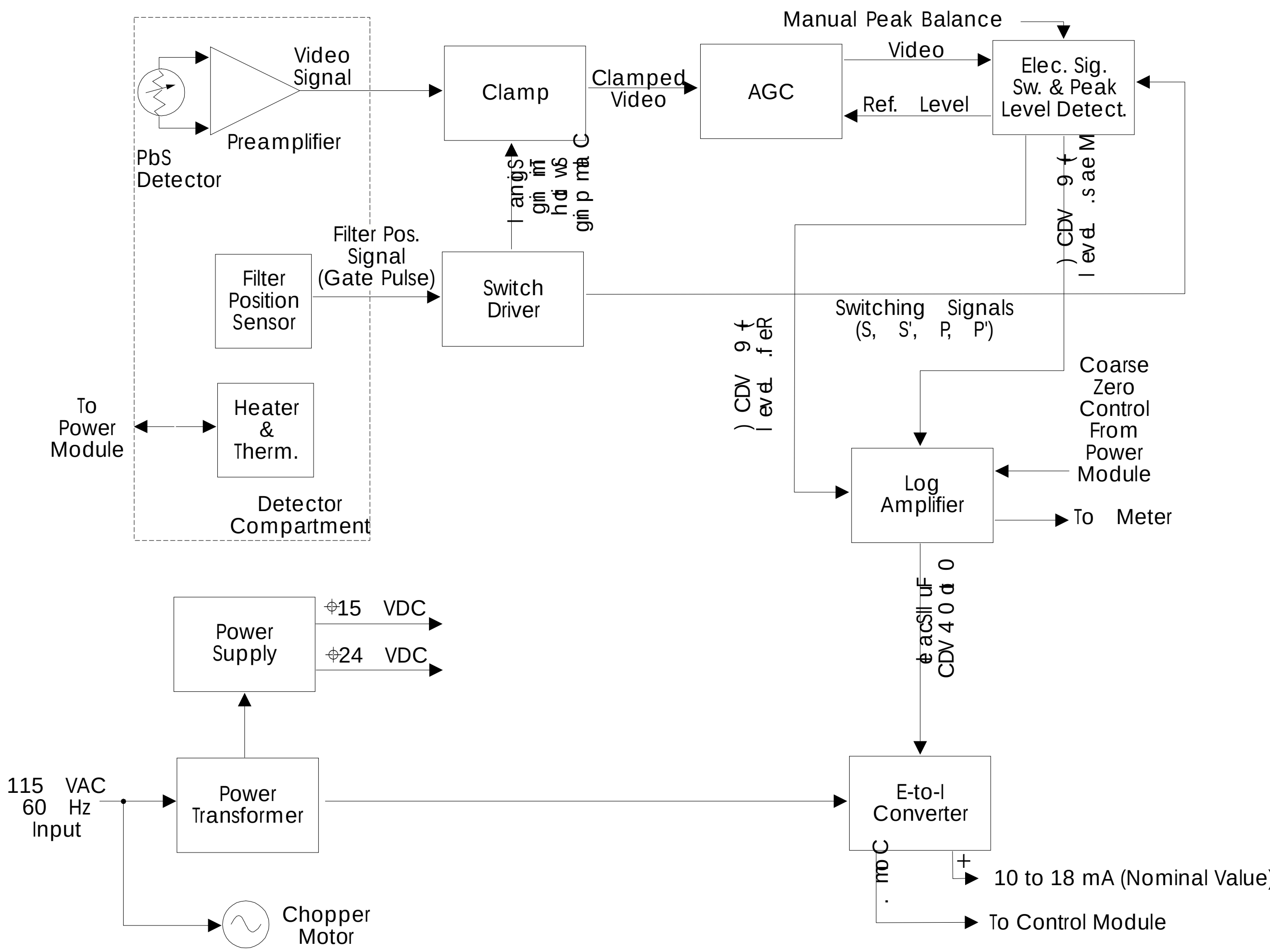


Figure 2-4. Detector Module - Block Diagram

Operating controls for the analysis section are located on the door casting of the power module enclosure. In the general purpose configuration, these controls include the POWER ON/OFF switch, the MEAS/REF switch to select the measuring or reference peak voltage to be fed to the local meter driver, ZERO control, and the NORM/ZERO switch, which operates in conjunction with the MEAS/REF and ZERO controls.

When used with the explosion-proof control module, the NORM/REF and NORM/MEAS switches are used on the module instead of the MEAS/REF switch. A NORM/ZERO switch is also included.

2.1.4 Detector Module

See Figure 2-4. After energy has passed through the sample, it arrives at the filter wheel where it is fed alternately through two filters (measuring and reference) before reaching the detector.

These filters are specially selected for each application according to the absorption characteristics of the compounds under analysis. The reference and measuring filter waveforms occur along a baseline at approximately 16 milliseconds intervals; each reference or measuring waveform reoccurs at a time interval of 33 mS, or one per revolution of the filter wheel.

At the detector, infrared energy is transformed into electrical pulses and fed through an impedance-matched preamplifier (see dwg. A-14619). Depending upon the application, length of the cell spacer, etc., the gain of the preamplifier may vary from 1 to 10, depending upon the energy intensity at the detector, to achieve an AC signal output of approximately 0.1 to 1.0 volt peak-to-peak.

Additionally, the detector, filters, and preamplifier are housed in an electrically and thermally isolated box to provide maximum stability and minimum noise. This box, or compartment, is normally temperature controlled at 46 °C.

The negative-going video from the preamplifier is fed to the clamp circuit (see dwg. B-14561) to establish a precise zero reference to the baseline of the pulses. This is accomplished by applying a gate to Ql at a time when neither filter is in the energy path. This gated signal is fed through A2 where it subtracts itself from the composite signal at the non-inverting input. The signal output of A3 is clamped to ground and has an amplitude of approximately two times the input.

The gating pulse for the clamp circuit is derived from the filter position sensor which is located in the detector compartment. The sensor emits radiation which is reflected from the white pattern on the rear side of the rotating filter wheel and sensed by a photo transistor. This creates a square wave of 5 volts amplitude at TP4 which is then further processed by Q2, A4 and A5 to generate the gating pulse for the clamp circuit as well as the switching signals S, S', P and P', which are later used to demodulate the composite video.

The clamped-to-ground, negative-going video is then sent to the automatic gain control circuit (see dwg. B-14564). This circuit receives a reference signal from the peak level detector and uses it to adjust the current through LEDs B1 and B2. The current through LED B1 controls its light output and, therefore, the resistance of its shunt resistors. This enables the signal at TP2 to be continually adjusted up or down to hold the reference signal at a constant level (nominally 9 volts) and thus eliminate the effects of turbidity or other foreign substances in the sample, within design limits.

After the automatic gain control circuit, the signal proceeds to the peak level detector, where it is demodulated by A1 and A2, using the timing signals previously generated (see dwg. B-14554). Potentiometer R3 can be used to precisely balance the signal levels by adjusting the feedback loop gain resistance of the two respective peaks. The separate peaks are then sent through peak detector networks where they are transformed into stable DC voltage levels. In the case of the reference peak level, it is from here that a +9 VDC signal is fed back to the automatic gain control network. The signal levels are then fed to either one of two logarithmic ratio amplifiers (see dwgs. C-14586 and C-14907).

For applications of high sensitivity, a chopper-stabilized log amplifier is used (see dwgs. C-14586 and C-17706). A3 generates an approximate 200 Hz square wave which alternately allows the signals to be fed into the log amplifier (A1) itself, and then blocks the measuring level and feeds the reference level into both log amplifier inputs, allowing it to zero itself. The log signal is then applied through amplifier A4 and A6 to A7 where a coarse zero offset voltage may be applied through the ZERO potentiometer on the power module

For less sensitive applications, a simpler log ratio circuit is used (dwg. C-14907). The reference and measuring levels are processed through a filter network before being compared by A1. This comparison results in the log ratio output which is fed to A2 for application to a zero offset voltage from the zero adjust potentiometer on the power module.

From the log amplifier the signal is finally sent to the voltage-to-current (E-to-I) converter for transmission to the control unit. Conversion of the voltage signal to a current signal allows for signal transmission over greater distances without noise pickup.

The E-to-I converter (see dwg. B-14075) is set with a nominal offset so that with 0 VDC input, 10 mA output is obtained. This baseline setting is adjustable through R7, the zero adjustment.

The converter is scaled so that with a 0.5 VDC input, the output will be 20 mA (set with balance potentiometer R12). Output nominally ranges from 10 mA to 18 mA with a 0 to 0.4 VDC input. When required, zero drift can be accommodated; i.e., inputs ranging from -0.5 to +0.5 VDC will produce 0 to 20 mA outputs.

Power for the detector module is provided by a center-tapped transformer which takes 115 VAC input, reduces it to 40 VAC, then feeds the voltage to the DC power supply. An additional winding on the transformer provides output power to the E-to-I card.

The power supply utilizes a fullwave rectifier in order to provide +24 VDC unregulated. The 24 VDC is further filtered, then fed through a voltage regulator to obtain +15 VDC regulated.

As noted previously, the filter wheel is driven by a synchronous AC chopper motor which operates at 1800 RPM. The filter wheel performs two functions: (1) switching filters, and (2) chopping the optical signal to give pulses which can be amplified for high quality processing.

2.1.5 Control Module

The control module provides voltage and current output signals which are properly scaled for the application, alarm signals in the form of relay contacts, and a meter output. Optional provisions are also included for an automatic zero and dual-range capability.

Upon arrival at the control module, the milliampere signal is converted to a 0 to +2 volt full scale output for connection to the span potentiometer (see dwg. A-14620). An optional millivolt output can also be provided by the I-to-E converter circuit card. At this point, fine zero control is also applied by means of a potentiometer located on the front of the module.

The voltage is then scaled so that 1 VDC full scale output is obtained at the center of the span potentiometer. This signal is coupled through an extended voltage amplifier circuit and used to drive the 0 to 100 µA meter on the control module.

The standard 0 to 1 VDC output is also generated by the extended voltage amplifier circuit (see dwg. B-16221).

The 0 to 1 VDC full scale from the span potentiometer is connected to the alarm comparator circuit (see dwg. B-14718) where it is used to drive a pair of amplifier circuits which couple the alarm setpoints to relays K1 and K2.

A current output (normally 4 to 20 mA) is optional. If desired, an optically isolated current transmitter can be installed in the explosion-proof control module.

Power for the control module is provided by a center-tapped transformer which takes the 115 VAC input, reduces it to 40 VAC, and feeds the voltage to a DC power supply identical to the one installed in the detector module. Power supply outputs are +24 VDC unregulated, and +15 VDC regulated.

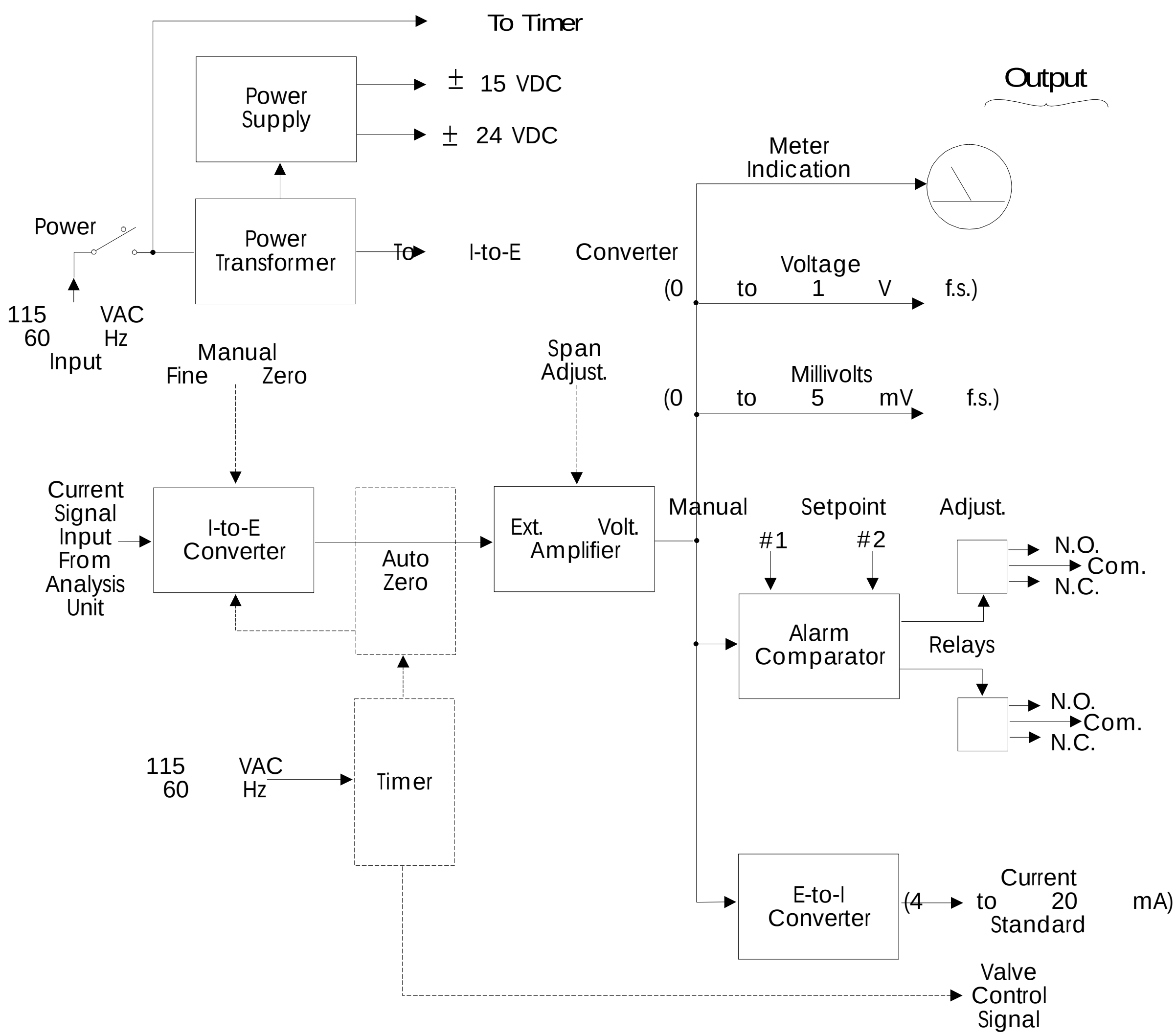


Figure 2-5. Control Module - Block Diagram

3.0 Installation

Before power is supplied to the analyzer, all modules should be opened and inspected for damage or loose components. Also check unit for proper wiring and connections. All plug in circuit cards should be removed and checked individually for correct assembly.

3.1 Location

The analysis section should be installed in an area where the ambient temperature does not fall below 32 °F or rise above 110 °F. Steam or electrical enclosure heating may be provided as an option. Do not install the assembly in the path of an air conditioner or in an extremely drafty area. The analysis section, as well as the explosion-proof version of the analyzer, is suitable for installation in Class I, Group D, Division I areas. Since the analysis section of the general purpose version of the analyzer is enclosed in a weather-resistant enclosure, it is suitable for outdoor location.

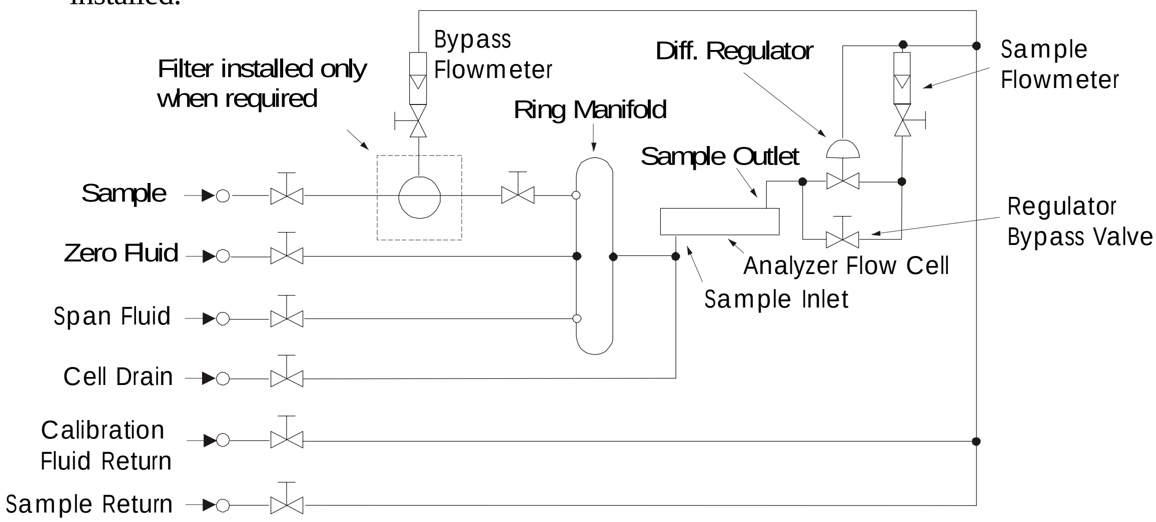
The control module of the general purpose version of the analyzer is generally intended for flush panel mounting indoors in general purpose areas.

3.2 Sample Section: Installation Recommendations

See Figure 3-1. The sample is introduced and drained (or vented) from two 1/8 " Swagelok bulkhead fittings located on the bottom side of the sample module. The following guidelines are recommended:

3.2.1 Filtering

Suspended particulate matter **must** be eliminated from the process sample prior to introduction into the analyzer sampling system. Aside from clogging the lines, accessories, integral sample paths of the analyzer and coating sample cell windows, solid particles may interfere with the analysis. TAI recommends that a bypass filter assembly in the sample loop be installed.



Figuire 3-1. Sampling Considerations

3.2.2 Effluent Return

Returning the sample effluent to the process may require a separate calibration fluid return so that the calibration fluids can be kept out of the process during standardization periods.

3.2.3 Flow Control

A differential pressure regulator is often used in TAI systems across the sample flowmeter and needle valve control to give a constant flow, regardless of upstream or downstream pressure fluctuations. Constant flow may or may not be important, depending upon the application.

It is necessary to insure sufficient contact of the sample with the preheater in order to bring the sample up to the control temperature. Do not allow flow in excess of 50 ml/minute.

For liquid applications, TAI recommends that the throttle valve and flowmeter always be downstream from the analyzer. Such an installation will pressurize the sample cell and eliminate bubbles in the sample. Bubbles suspended in the sample fluid will produce erratic, ambiguous analysis of the sample.

The cell with sapphire windows will withstand up to 600 psi pressure. TAI does not recommend high pressure sample handling, but don't hesitate to slightly pressurize the analyzer for optimum results.

3.2.4 Selector Manifold

TAI recommends a three valve selection system that reports into a "ring" manifold for sample and calibration fluid control. Such a system will permit you to conserve calibration fluid. Calibration fluids can be introduced by a simple gravity system. A bypass valve around the differential pressure regulator is recommended for calibrating with gravity feed. Calibration fluid flow need only be long enough to insure adequate flushing of the system, and then the calibration fluid drain valve can be closed. A ring manifold will insure a good flush with a minimum expenditure of fluid.

3.2.5 Automatic Zero Operation

Analyzers equipped with automatic zero control will require a three-way electrically or pneumatically actuated valve in the sample system. In addition, if it is undesirable for zero fluid to return to the process, a similar three-way valve must be used for the calibration fluid return. In addition, a time delay on the operation of the second three-way valve is desirable to allow sample fluid purging of the zero fluid in the analyzer returning to the process stream. This time delay must be built into the analyzer at the time of purchase.

With automatic zeroing, zero fluid can be actuated manually by setting the SAMPLE-ZERO switch to the ZERO position. Span fluid is introduced by setting the switch to SPAN.

3.3 Electrical Installation

3.3.1 Power Check

1. Plug in the +15 volt power supply PC card (see dwg. B-14708) but leave all other PC boards out.
2. Turn power ON.
3. With a digital multimeter (DMM), check for +15 volts on the +15 volt power supply.
4. Check for proper starting of the chopper motor and source lamp.

WARNING: The light intensity from the quartz iodine lamp is intense and should not be looked at directly without special protective eyewear. Protective goggles with shaded lenses (Fed. Spec. #5) should be worn if it is necessary to look directly at the source.

Explosion-Proof Version

See dwg. B-16571.

Control module power in:

TS2-14: Hot
TS2-13: Neutral
TS2-12: Ground

Control module output:

TS2-1 (Com), TS2-2 (+) } 0-1 V output
TS2-3 (Com), TS2-4 (+) } mA output
TS2-10 (Com), TS2-9 (+) } mV output
TS1-1 (-), TS1-2 (+) } mA output (isolated)
TS1-6 (Com), TS1-7 (N.O.), TS1-8 (N.C.) } alarm relay K1
TS1-9 (Com), TS1-10 (N.O.), TS1-11 (N.C.) } alarm relay K2

NOTE: In order to maintain the explosion-proof integrity of the system, interconnecting wiring between the power and control modules is performed by TAI.

General Purpose (Control Module Remote)

See dwg. C-15245.

Control Module Power In:

TS2-14: Hot
TS2-15: Neutral
TS2-16: Ground

Power Module Power In:

TS1-1: Hot
TS1-2: Neutral
TS1-3: Ground

Control Module (mA Input):

mA output { + - TS2-7 from TS2-7 } Power module
Com - TS2-8 from TS2-6

Control Module Output:

TS2-1 (Com) } 0-1 V output
TS2-2 (+)

TS2-3 (Com) } mA output
TS2-4 (+)

TS2-10 (Com) } mV output
TS2-9 (+)

TS2-12 (Com)
TS2-11 (N.O.) } alarm relay K1
TS2-13 (N.C.)

TS1-12 (Com)
TS1-11 (N.O.) } alarm relay K2
TS1-13 (N.C.)

3.4 Analysis Unit

Explosion-Proof Version, Control Unit: Input power connections for this unit are at TS2 pins: 12 (ground), 13 (neutral), 14 (line) (see dwg. B-16571). The input resistance between line and neutral with the ON/OFF switch in the ON position should be 4 ohms +10%. The resistance between ground-hot and ground-neutral should be infinite resistance.

General Purpose Version, Control Unit: Control unit input power connections are to be found at TS2 pins: 14 (line), 15 (neutral), 16 (ground) (see dwg. C-15245). The input resistance between line and neutral with the ON/OFF switch in the ON position should be infinite resistance.

General Purpose Version, Power Module: Power Module input power connections are at TS1 pins: -1 (line), -2 (neutral), -3 (ground) (see dwg. C-15245). The input resistance between line and neutral with the ON/OFF switch in the ON position should be 5 ohms +10%. The resistance between ground-line and ground-neutral should be infinite resistance. At this point all interconnections between the control unit and power module should be made. The interconnections are as follows: Connect the input AC power to TS2: -14 (line), -15 (neutral), -16 (ground).

Next, a power line connection should be installed between the control unit switch AC power in TS1: -14 (line), -15 (neutral), -16 (ground), and the power module AC power in TS1: -1 (line), -2 (neutral), -3 (ground).

Signal connections should now be installed from the control unit TS2: -7 (plus), 6 (common) (see dwg. C-15245).

3.5 Optical Alignment

The object of optical alignment is to bring the optimum source energy to the detector. Generally the optimum energy will be the maximum amount of energy which can be focused on to the detector. This can be done by adjusting the various elements in the source module (see dwg. C-14628).

WARNING: The light intensity from the quartz iodine lamp is intense and should not be looked at directly without special protective eyewear. Protective goggles with shaded lenses (Fed. Spec. #5) should be worn if it is necessary to look directly at the source.

Use a Variac on the input AC line to reduce the voltage and the lamp intensity to a tolerable level.

1. Vertical lamp position is achieved by loosening the screws of the base lamp bracket and moving the assembly up or down.

2. Horizontal position is achieved by loosening the Allen screw at the base of the lamp holder which allows side to side movement of the lamp.

3. Beam focusing is then achieved by loosening the lens holding bracket and moving the lens back and forth until the best focusing is obtained.

4. First visually optimize the lamp energy using a white piece of paper at various locations in the light path. Make adjustments as in steps 1, 2, and 3 above.

5. Then electronically optimize the energy as follows (the preamp must be installed in the detector compartment):

    a. Insert an extender card in the switch driver and clamp position (remove keys as necessary).
    b. Connect an oscilloscope to pin 6 (video from pre-amp), and pin 3 (ground).
    c. Remove the lens assembly from the light path.
    d. Optimize lamp energy by adjusting the lamp position as described in steps 1 and 2 above.
    e. Replace the lens assembly.
    f. Focus the lamp as described in step 3 to give the maximum peak heights displayed on the oscilloscope.
    g. If a Variac was used to alter the light intensity, disconnect it and reconnect source to power supply.

4.0 Operations

Before shipment, TAI calibrates the analyzer for your application when feasible. Calibration data is listed in the Appendix. Prior to calibration, TAI checks the electronics of the analyzer and makes all of the necessary internal printed circuit board adjustments. Calibration is performed to determine the proper zero and span settings, and also to verify that the analyzer response is linear.

After calibration, TAI makes a lengthy stability check to insure that the analyzer performs within all specifications. We advise that you recalibrate your equipment as part of start-up for the following reasons:

1. During shipment, it is possible that components have been jarred out of position or damaged.

2. Your process may be of a proprietary nature. Beyond checking electrical stability, TAI is unable to make a meaningful calibration of the system, requiring these adjustments to be made by you.

3. In other cases precise calibration can only be made with the analyzer connected to your process stream.

In any case, it is important that you calibrate the analyzer when it is first installed. Zero checks should be made routinely once or twice a week and span calibration should be performed weekly, at first, and monthly after reproducibility is assured.

4.1 Control Functions

4.1.1 General Purpose Version, Analysis Section

The control functions for the analysis section are located on the power module:

1. POWER ON/OFF: This switch controls power to the analysis section.

2. NORM/ZERO: NORM setting gives a local meter reading of the peak-to-peak (P-P) voltage of the measuring or reference signal, depending upon the mode setting of the MEAS/REF switch.
   ZERO setting allows the meter to display the voltage output of the analysis section after comparing the logarithm of the measuring and reference signals. This output is fed to meter driver prior to conversion to a current signal for transmission to the control module.
   With zero fluid in the cell, the analysis section local meter should read zero when the NORM/ZERO control is set to ZERO. The setting of the MEAS/REF switch has no effect on meter readout in the ZERO position of this switch.

3. MEAS/REF: selects either the measuring or reference peak voltage to be fed to the local meter driver. The NORM/ZERO switch must be in the NORM position; the reference peak voltage should read 9±0.1 volts. With zero fluid in the sample cell, the measuring peak voltage should be the same as the reference peak voltage.

4. ZERO: potentiometer control allows an adjustment of the analysis section output voltage to the E-to-I converter. The ZERO control should be adjusted to give a zero reading when zero fluid is in the sample cell.

5. Local Meter Readout: reads reference or measuring peak heights, or voltage output from buffer amplifier before E-to-I conversion.

4.1.2 General Purpose Version, Control Module

1. ZERO: control to adjust the control module to read zero output when zero fluid is in the sample cell, i.e., fine zero.

2. SPAN: control to adjust the span calibration to make the control module meter read the correct concentration of the span fluid.

3. POWER ON/OFF: This switch controls power to the control module.

4. ALARM SET (#l and #2): optional controls; position of dial setting determines alarm setpoints. If dual alarms are used, these may be set for high/low, high/high or low/low. Single alarms can be either high or low. Dial settings can be determined from the following formula:

   X = Unknown dial setting to achieve desired alarm setpoint.
   A = Analysis scale unit for low end of range.
   B = Analysis scale unit for high end of range.
   C = Analysis scale unit desired for alarm setpoint.

$$X = \frac{(C-A)(1000)}{(B-A)}$$

For example, if the range of analysis is 20-80%, and a desirable alarm setpoint is 30%, then A = 20, B = 80, and C = 30

$$X = \frac{(30-20)(1000)}{(80-20)} = 167$$

5. RANGE: optional switch; allows changing the range by some predetermined amount, such as 4X or 5X; i.e., dual range: low range of 0-100 ppm and a high range of 0-500 ppm.

6. Mode: selector for units incorporating an automatic zero. SAMPLE position is the automatic zero; ZERO position is the manual zero; SPAN position is the manual span adjustment.

7. Meter Readout: indicates the concentration of the component of interest.

4.1.3 Explosion-Proof Version: Control Module

When the control module is integral with the analysis section (explosion-proof), it has all of the same control functions as the remote control module. However, the meter readout function will be performed by the analysis section.

Since the meter readout must handle functions for both the analysis section and the control module, some of the controls on the power module are different from those on the general purpose unit.

The NORM/REF and NORM/MEAS switches are on the power module in place of the MEAS/REF switch. In addition, the NORM/ZERO switch is located on the power module.

To read output from the control module, the NORM/ZERO, NORM/REF and NORM/MEAS switches all must be in the NORM position.

4.2 Start-up

Information contained in this paragraph is based on the premise that the analyzer has been properly installed as outlined in Chapter 3.0, and that it is in operable condition. If difficulties arise during start-up, it is probable that some form of damage has incurred during shipment or some installation error has inadvertently been made.

Accessory test equipment is not necessary for start-up of the 514. However, if the analyzer malfunctions at start-up, an oscilloscope and a multimeter will be required for troubleshooting (see Chapter 5.0). TAI recommends that a dual trace oscilloscope be used. A dual trace oscilloscope will permit the operator to see two different waveforms simultaneously.

4.2.1 Preliminary Inspection

Before power is supplied to the analyzer, all modules should be opened and inspected for damage or loose components. Plug-in circuit cards should be firmly seated in their sockets. All barrier strip wiring connections must be inspected, and user-installed wiring between units verified as being in agreement with the system interconnection diagram.

Control Settings

Prior to turning on the power, the controls on and within the control module should be positioned as follows:

Analyzers not equipped with Auto Zero

1. ON/OFF switches on OFF.
2. SPAN control preset to the setting noted in Specific Application Data in the Appendix.

Analyzers equipped with Auto Zero

1. ON/OFF switches on OFF.
2. SAMPLE/ZERO switch on ZERO.
3. RUN/TEST switch (on timer unit within control module) in TEST position.

4. SPAN control preset to the setting noted in Specific Application Data in the Appendix.

4.2.2 Pre-Start-up Electrical Checkout

After the preliminary procedures have been accomplished (refer to Preliminary Inspection and Control Settings, above), the integrity of the system interconnection and the power sources must be verified before attempting the analytical start-up procedures.

The observations and measurements described in the following paragraphs are vital to the operation of the analyzer. If the analyzer does not respond as described, the equipment has been damaged in shipment or installation, or the user-installed wiring is in error. If a problem arises, correct it before proceeding further.

The following procedures should be employed in the same sequence in which they appear.

4.2.3 Power On Observations

Turn both the analysis section and control module ON/OFF switches to ON and make the following observations:

1. Open the analysis section detector module and verify that the chopper motor is operating. The motor should start turning the instant power is established. If it does not, check the integrity of the main fuse on the control module door. If the fuse is blown, re-check the power service connections on TS2 in the control module, and the control module to analysis section interconnection wiring (refer to Electrical Installation in Chapter 3.0: Installation, and dwg. C-15245).

2. The lamp source should light the instant power is established. Open the cover on the source module to verify illumination.

WARNING: 1. The light intensity from the quartz iodine lamp is intense and should not be looked at directly without special protective eyewear. Protective goggles with shaded lenses (Fed. Spec. #5) should be worn if it is necessary to look directly at the source.
2. Before opening any of the enclosure covers with the power on, make certain that the area has been classified as safe to do so.

3. If the analyzer section has been equipped with the automatic zero option, the zero solenoid device in the accessory sampling system

should have energized the instant power was established. The device (or devices) should be energized because the mode switch has been preset to the ZERO position.

4. If the test procedure was normal, the devices should have been seen or heard to operate as described by personnel located at the analysis section installation site, and no further check need be made at this time. If operation is not as described, refer to Troubleshooting in Chapter 5.0.

5. Check analyzer operation by completing the calibration procedure described below in Calibration after allowing the instrument to warm up. The electrical circuits take from 30 to 40 minutes to stabilize.

NOTE: It will take at least four hours for the analyzer to completely stabilize with respect to temperature.

4.3 Calibration

Standardization Fluids

Two standardization fluids are necessary to calibrate the analyzer:

1. Zero Fluid: The zero standard fluid must have a composition similar to the sample, and ideally, contains none of the components of interest. The zero fluid should be laboratory analyzed to determine its composition. The exact composition must be known, as the accuracy of the analysis can be no better than the your knowledge of the standardization fluid.

2. Span Fluid: The span fluid must be representative of the sample fluid in composition (like the zero fluid), and contain a measured quantity of the component of interest. The component of interest content of the fluid should be in the region of 75% to 100% of the range of measurement. As with the zero fluid, the accuracy of the system is dependent upon the your knowledge of the span fluid composition. Ideally, the span sample should contain 100% of whatever the instrument is set up to analyze.

Procedure

1. Introduce zero fluid (see above) into the sample cell. Flow **liquid samples** into the cell at a flow rate of less than 50 ml/minute to allow the sample preheater time to heat the sample up to the

control temperature. Make certain that bubbles are not introduced or formed in the cell. (Some back-pressure may help avoid this.) **Gas samples** can be introduced at about 200 ml/minute.

2. Turn the power module NORM/ZERO switch to NORM.

3. Turn the power module MEAS/REF switch to REF. Verify that the analysis section meter reads 9±0.1 volts.

4. Make adjustment of the measuring peak voltage as follows (zero fluid must be in the sample cell during this adjustment):

    a. Switch the MEAS/REF switch to the MEAS position. The meter should read almost the same as in the REF mode. If the reading is somewhat different, the measuring peak may be re-adjusted with R3 on the peak level detector circuit card (see dwg. B-14554 and "Peak Level Detector" in Chapter 5) inside the detector module.

    b. If the measuring peak is so far out of balance with the reference peak that it can no longer be adjusted with potentiometer R3, the optical filters require re-screening. If the analyzer has been in use for some time, it is possible that the sample cell windows need cleaning or that a filter has deteriorated.
    Another cause of peak imbalance might be that the sample chemical background has changed. In some cases, TAI is not able to duplicate the background your sample for purposes of optically balancing the analyzer before shipment. In these cases, it is necessary for you to screen for an approximate balance, and to then electronically adjust R3 for precise balance. To do so:
    1. Reset R3 to its midpoint.
    2. Re-screen the filter wheel, as necessary, to obtain a measuring voltage within 10% of the reference voltage. Every time a screen is added or removed from a filter, the analyzer must be turned off, and the filter wheel removed from the analyzer. When the filter wheel is replaced in the analyzer, its rotational position is not critical, but the white backing must face in the direction of the position sensor. The filter wheel must also be securely tightened, so that no slippage or vibration can occur. See Figure 5-1.

NOTE: Refer to Figure 5-1 when installing filter screens. Screens should be installed in the filter disk cup, under the filter holder. Also, if a

balance ring is used, it should be placed over the screen.

c. After screening to bring the measuring voltage to within 10% of the reference voltage, adjust R3 as in step a above to make the measuring peak voltage read the same as the reference peak voltage.

5. Turn the NORM/ZERO switch to ZERO. The analysis section meter should be made to read zero by adjusting the coarse ZERO control on the analysis section power module.

6. Check the control module SPAN setting to make sure it agrees with the calibration results obtained by TAI (see Specific Application Data in the Appendix).

7. Adjust the ZERO control on the control module to give a zero reading on the control module meter.

8. Add span fluid (see Span Fluid, above) to the sample cell. Make certain that all of the zero fluid is displaced.

9. Adjust the control module SPAN control to obtain the correct meter reading with reference to the concentration of span fluid. For example, if the sample contains 100% of whatever the instrument is set up to analyze, then the SPAN control must be adjusted for a full scale reading, i. e., 200 ppm water in EDC.

10. Re-check the ZERO setting with zero fluid.

11. If desired, the linearity of the analyzer can be checked with a fluid intermediate in concentration between the zero and the span fluid.

12. The analyzer is now calibrated. It is often desirable to check calibration (fine tune) on a dynamic sample from your process, double checking the 514 analyzer response with laboratory analyzed grab samples. This is desirable where there is a possibility that your sample stream may have some background materials not in the makeup of the calibration fluid.

13. From time to time, re-check the zero setting. If it is found that there is no zero drift, re-checking the zero setting may become unnecessary or may be performed only on an occasional basis.

14. Some optical filters used in some applications will be so temperature sensitive that screening must be performed with the filters near the operating temperature.

5.0 Maintenance & Troubleshooting

Under normal operating conditions, little or no maintenance is required. When, after prolonged use, the sample cell builds up an accumulation of dirt or particulate deposits that take the instrument out of range of the ZERO controls, then the sample cell must be removed (see Figure 5-2) and the optics cleaned.

The filters should also be checked to see if any deposits have accumulated on their surfaces, requiring cleaning. Also, carefully inspect the filters for any signs of deterioration. If necessary, remove and replace filter(s) (see Figure 5-1). If optics/filters require cleaning, proceed as follows:

1. Windows are synthetic sapphire and lenses are quartz. They can be cleaned, if necessary, with mild detergent and water, or with a solvent such as ethanol.

2. The filters are sensitive to moisture and can be damaged by water. They are held in place with epoxy cement which may be attacked by solvents. Therefore, if filters must be cleaned beyond the removal of dust with a brush, they may be cleaned by application of ethanol with a cotton-tipped swab, being careful not to wet the epoxy cement.

CAUTION: Extreme care must be observed when cleaning the optics of the analyzer, particularly the reference and measuring filter elements, which are critical, coated interference-type filters. Do not use abrasive cleaners of any type. Dust or dirt can be removed with a camel's hair brush.

Periodic lamp replacement may be necessary. This is performed by disconnecting the old lamp, removing it, and reconnecting the leads of a replacement lamp.

With the exception of the items noted above, the analyzer system is virtually maintenance-free and should perform satisfactorily almost indefinitely.

5.1 Replacement of Sample Cell Optics

If it becomes necessary to remove the sample cell optics for cleaning, proceed as follows (see dwg. C-14631):

1. Loosen the bulkhead nuts on the two Swagelok fittings located on the bottom of the condulet.
2. Remove the four mounting screws that secure the backplate to the condulet interior.
3. Remove the two top mounting screws for sample preheater.
4. Unclip heater assembly from top of the compartment.
5. Remove two bulkhead fittings for clearance, then remove entire, wired backplate assembly. There is no need to remove the wire connections to the terminal strips. However, observe caution when removing backplate from condulet; make sure that wire is not twisted or pulled from connections.
6. Disassemble sample cell (see Figure 5-2).
7. To reinstall the sample cell, reverse the removal/disassembly procedure.

5.2 Replacement of Filter Wheel Optics

If it becomes necessary to replace filter wheel optics, or re-screen filter(s), proceed as follows:

1. Remove four screws securing detector compartment cover; remove cover from compartment.
2. Use long-handled Allen-head wrench (7/64") to remove filter wheel from chopper motor shaft. Hold filter wheel steady, insert wrench in sockethead screw, then rotate shaft to remove the screw and washers.
3. Carefully remove the filter wheel. Make certain that filter is not touched with fingers, scratched, or marred in any way. Oil from the fingers, or merely a fingerprint on the filters, can seriously degrade performance of the analyzer.

4. A total of six spare screens are furnished with the analyzer system. As shown in Figure 5-1, the screens are placed under the filters. Re-screen, as required, then reassemble filter wheel and install by reversing the removal/disassembly procedure. Make sure to reassemble any balance weights or, if balancing facilities are available, re-balance filter wheel if re-screening has resulted in a weight shift.

5. **It is extremely important that the filters are not interchanged.** The measuring filter is located adjacent to the white arc on the filter wheel. If the filters are interchanged, meter readings will be reversed, i. e., the meter will indicate downscale values instead of upscale.

5.3 Replacement of Source Lamp Assembly

The replacement source lamp assembly is installed in place with the evacuation seal oriented toward the right side of the module, i. e., away from the lens. Make lamp electrical connections to terminals TS1-3 and TS1-4 (green leads).

After replacement, it may be necessary to adjust the lens associated with the source lamp. Two screws secure the lens mount by means of slotted mounting holes, permitting horizontal and vertical adjustment of the lens. Likewise, the screw securing the source lamp mount can be loosened, allowing movement of the lamp for adjustment purposes. After adjustment, re-tighten all mounting screws. Make adjustments as follows:

1. Disconnect power originating in the power module (line voltage regulating transformer) by removing the leads from TS1-1 and TS1-2 in the source module.

2. Connect lamp transformer primary terminals (black, black-red leads) to a source of adjustable AC (Variac, Powerstat, etc.).

3. Energize the source lamp sufficiently to make the optical adjustment; however, do not make source lamp illumination so excessive that brightness can harm the eyes or make the mount too hot to handle.

4. Move the lamp until the light can be seen centered in the optical tube separating the source and sample modules.

5. Using an oscilloscope, check the AC video signal at TP1 of automatic gain control card (see dwg. B-14564). Maximize the signal output with the adjustment, then tighten all screws in the lens and lamp mounts

6. If an oscilloscope is not available, remove the filter wheel (see Figure 5-1) and place a sheet of white paper in front of the detector. Then adjust the lamp until the brightest, most uniform spot of light is obtained. Avoid dark spots in the middle or sides. The light shining on the detector may be viewed with a dental mirror. Make certain that the detector is completely covered with light.

NOTE: Do not touch the source lamp with fingers. The envelope must be clean. If necessary, clean with mild detergent and water or solvent.

5.4 Replacement of Filter Position Sensor

The filter position sensor is installed within the detector compartment; the sensor is secured to its mount by a single 4-40 screw. To replace the sensor, proceed as follows:

1. Remove the four screws securing the detector compartment cover; remove the cover from compartment.

2. Remove mounting screw. Pull the sensor free from its mount.

3. Tag all wiring, then cut the wiring to the sensor.

4. Splice new wiring and cover with shrink tubing. The sensor “tail” should be removed so that the space between the sensor and the filter wheel is approximately 1/8 ".

5. After all wiring has been made and the spacing is correct, secure filter position sensor with 4-40 screw.

5.5 Replacement of Preamplifier Circuit Card

The preamplifier circuit card is installed inside a preamplifier subassembly which, in turn, is located within the detector compartment. To replace the preamplifier circuit card, proceed as follows (see dwg. D-14665 and C-14667):

1. Remove four screws securing detector compartment cover; remove cover from compartment.

2. Loosen bottom nut on coaxial connector so that connector can be pulled free of the receptacle.

3. Remove mounting screw used to secure subassembly base to detector compartment interior.

4. Release the subassembly box from its mounting flange and carefully remove it from the compartment. The two additional connectors are the slip-on type and can be slipped off of their receptacles as the subassembly is removed.

5. After the subassembly box is removed, the box can be opened for removal of the circuit card.

6. Make certain that the slipon connectors are properly installed and that the nut is tightened on the coaxial connector. Reverse the removal procedure to finish reinstallation.

5.6 Re-screening of Lens

Gain resistor R4 in the preamplifier establishes the voltage output to the clamp circuit (see dwg. A-14619). The resistor is selected for the application. If there is too much light for a particular application, R4 is reduced to approximately 1 megohm. If there is still too much light, the light path can be attenuated by installation of a screen in the lens holder, held in position by the installed lens.

5.7 Troubleshooting

When troubleshooting the analyzer, it may be helpful to note that the reference and measuring level signals are split at the peak level detector. Thus, if one of the signals is faulty but not the other, it might be an indication of a malfunction in the peak detector circuit card, ahead of the log amplifier. If the meter indications are the same, but too high or too low, it may be an indication that something is malfunctioning ahead of the peak detector circuit.

Use waveforms and voltages in this section to isolate troubles to specific components or circuits.

In the event of an electronic malfunction, always check the power supply voltages before starting a detailed troubleshooting procedure.

The voltages given in the waveform and voltage tabulations are not necessarily exact under all operating conditions. Depending upon the application and various potentiometric adjustments, they may vary. They are

Symptom	Cause	Corrective Action
Calibration voltages near zero on local analysis meter (less than standard 9 VDC).	Source lamp burned out.	Check lamp and replace, if necessary. After replacement, adjust optics (refer to section ×).
Shift in readings at concentration meter.	Changes in voltage to source lamp, i.e., changes in line voltage supply to lamp.	Check transformer at source lamp module; replace, if necessary. Check line voltage regulating transformer in power module; replace, if necessary.
Noisy output at concentration meter (or noisy recorder trace).	Preamplifier not providing a strong enough output signal.	Check preamplifier output signal. Use either J3 at preamplifier or connector pin 6 at switch driver. Replace preamplifier circuit card, if necessary.
Trace wanders (erratic or noisy signal at concentration meter.)	Source lamp burned out.	Check voltage at calibration meter. If both voltages are well below 9 VDC, check/ replace source lamp.
Nonlinear output as a function of concentration of the sample; output noisy.	Clamp circuit defective (signal not clamped to ground).	Check for clamped video input to auto. gain control (check TP1); replace switch driver and clamp circuit card, if required. Check switch signal outputs from switch driver and clamp circuit card: P, P', S, and S'.
Concentration meter operates backwards; meter deflection is from right to left.	Filters in filter wheel installed incorrectly.	Check filter installation. The measuring filter should be installed adjacent to the white painted arc (see Figure 5-1).

Symptom	Cause	Corrective Action
Output goes to zero or full scale (either extreme).	E-to-I converter defective (check output transistors Q3, Q4 or Q5).	Check/replace, if required. If meter sits on zero, also check auto. gain control circuit card; replace, if required.
	Failure of A1 IC (log amplifier) in log amplifier circuit.	Check log amplifier for 0 to 0.4 VDC full scale output. If IC A1 is replaced, make sure that balance potentiometers are adjusted. Refer to Table VI.
	Failure of I-to-E converter.	Check input to pin 14. If input is correct, check output at pin 15 for 0 to +4 VDC full scale. Replace I-to-E converter, if required.
	Failure of extended voltage amplifier.	Check input at pin 2 and output at pin 5. If pin 5 output voltage is not 0-1 VDC full scale output, check/replace circuit card.
Discrepancy between recorder trace (current) and reading on concentration meter.	E-to-I converter defective.	Check/replace, if required. Pay particular attention to the output transistors (Q3, Q4 and Q5). Check/replace fuse F1, if necessary.
Output drifts slowly up or down.	Defect in temperature controller circuitry.	Check/replace temperature controller circuit card, as required.

Secondary Adjustments

Ref. Desig.	Location	Function
Detector Module		
R7 (20K)	E-to-I Converter (sch. B-14075)	Zero adjustment—adjusts output at 10 mA for 0 VDC input.
R12 (500 ohms)	E-to-I Converter (sch. B-14075)	Balance adjustment—adjusts output at 20 mA for 0.5 VDC input.
R15 (1K)	Log Amplifier (sch. C-14907)	Span adjustment (coupled with factory select R8 and R16)—adjusts output of A2 for 0.4 VDC full scale.
R26 (10K)	Log Amplifier (sch. C-14907)	Meter trim adjustment—adjusts meter driver and amplifier.
R7, R9 (2K each)	Log Amplifier (sch. C-14907)	Balance adjustments for logarithmic amplifier A1 (see Note 1).
R16 (1K)	Log Amplifier (sch. C-14586)	Span adjustment (coupled with factory select R13 and R17)—adjusts output of A7 (signal to E-to-I converter) for 0.4 VDC full scale.
R36 (20K)	Log Amplifier (sch. C-14586)	Meter trim adjustment—adjusts meter driver and amplifier.
R10, R11 (2K each)	Log Amplifier (sch. C-14586)	Balance adjustments for logarithmic amplifier A1 (see Note 2).
R3 (10K)	Peak Level Detector (sch. B-14554)	Peak level balancing adjustment—balances signal levels of reference and measuring voltages (on local calibration meter).
P2 (10K)	Automatic Gain Control (sch. B-14564)	Reference voltage level adjustment for automatic gain circuit—sets the voltage to whlch the auto. gain control will hold the reference peaks. To set, switch calibration meter to "reference" and read the reference level on the meter. Adjust for +9 VDC which is the nominal value used.
Control Module		
R1 (10K)	Extended Voltage Amplifier (sch. B-16221)	Adjusts offset of Q1 amplifier.
R5 (5K)	Extended Voltage Amplifier (sch. B-16221)	Meter trim potentiometer.
R2 (10K)	Alarm Comparator (sch. B-14718)	Alarrn setpoint trim potentiometer.

given more as an indication of magnitudes to be expected rather than as exact values.

The troubleshooting chart cannot possibly identify all malfunctions that may occur. Isolate the malfunction by using the waveform/voltage information, then replace the suspected circuit card.

All schematic and and circuit assemblies are given in the Drawing List in the Appendix.

Adjustment of R7 and R9 on Log Ratio Amplifier Circuit Card

When the log amplifier integrated circuit (A1) is replaced on the log ratio amplifier circuit card, it is necessary to readjust potentiometers R7 and R9 in order to balance the circuit.

In order to make the adjustments, have an extender card, a 100K resistor for connection between A1-2 and A1-7 (across C5), and a high-impedance voltmeter handy to measure the voltage between A1-7 and connector pin 9.

Proceed as follows:

1. Temporarily install 100K resistor across A1-2 and A1-7 (across C5).
2. Disconnect connector pin 9 from 9 VDC by lifting a connection on the extender card. Connect pin 9 of printed circuit card to A1-1 (signal common).
3. Adjust R7 until the voltage measured at A1-7 is zero.
4. Remove 100K resistor from A1-2 and
5. Reconnect connector pin 9 to 9 VDC.
6. Using a high-impedance voltmeter to measure voltages at pins 7 and 9 of the card extender, adjust R3 on the peak detector circuit card until they are equal. With the reference and measuring voltages equal and at approximately 9 volts, adjust R9 of the log circuit card until the voltage at A1-10 is zero.
7. The log amplifier module (A1) is now balanced.

Adjustment of R10 and R11 on Chopper-Stabilized Log Amplifier Circuit Card

When the log amplifier integrated circuit (A1) is replaced on the chopper-stabilized log amplifier circuit card, it is necessary to readjust potentiometers R10 and R11 in order to balance the circuit.

In order to make the necessary adjustments, it is necessary to have an extender card, one 20KΩ resistor, and a high impedance voltmeter.

Proceed as follows:

1. Use an extender card so that connections are accessible
2. Temporarily connect a 20K resistor (stable, not composition type) between A1-2 and A1-7 (across C2).
3. Unplug A2, A3 and A5.
4. Jumper A5-7 to A5-5 at socket and A2-3 to A2-6 at socket.
5. Install card in card extender and turn on analysis unit power.
6. Verify that voltage to pin 7 of the card edge connector is approximately 9 VDC (measure between pin 7 and pin 14).
7. Adjust potentiometer R10 until the voltage measured at A1-7 is zero with respect to signal common (TP3).
8. Remove jumpers installed in step (4).
9. Remove resistor connected in step (2).
10. Disconnect connector pin 7 from input by lifting a connection on the extender card.
11. Temporarily connect a 20K resistor between A5-7 and A5-15 to A1-16.
12. Jumper between A5-6 and A5-7 to provide the 9 VDC through 20K into A1-2 and through 20K into A1-16.
13. Adjust potentiometer R11 until the voltage measured at TP2 is zero.

14. The log amplifier integrated circuit (A1) is now balanced.
15. Remove the 20K resistor, the jumper, restore connections, replace ICs, then turn on the instrument power and check control loop by measuring voltage at the output of A2. Voltage should be -3 VDC, nominal.
16. If voltage is positive, R11 is out of balance or a component in the loop has failed.

Photometric Laboratory Adjustment Procedure

Before power is supplied to the analyzer, all modules should be opened and inspected for damage or loose components also check unit for proper wiring and connections. All plug in circuit cards should be removed and checked individually for correct assembly.

Analysis Unit

Explosion-Proof Version, Control Unit: Input power connections for this unit are at TS2 pins: 12 (ground), 13 (neutral) 14 (line) (see dwg. B-16571). The input resistance between line and neutral with ON/OFF switch in the ON position should be 4 ohms +10%. The resistance between ground-hot and ground-neutral should be infinite resistance.

General Purpose Version, Control Unit: Control unit input power connections are to be found at TS2 pins: 14 (line), 15 (neutral), 16 (ground) (see dwg. C-15245). The input resistance between line and neutral with ON/OFF switch in the ON position should be infinite resistance

General Purpose Version, Power Module: Power Module input power connections are at TS1 pins: -1 (line), -2 (neutral), -3 (ground) (see dwg. C-15245). The input resistance between line and neutral with ON/OFF switch in the ON position should be 5 ohms +10%. The resistance between ground-line and ground-neutral should be infinite resistance. At this point all interconnections between the control unit and power module should be made. The interconnections are as follows: Connect the input AC power to TS2: -14 (line), -15 (neutral), -16 (ground).

Next, a power line connection should be installed between the control unit switch AC power in TS1: -14 (line), -15 (neutral), -16 (ground) and the power module AC power in TS1: -1 (line), -2 (neutral), -3 (ground). Signal connections should now be installed from the control unit TS2: -7 (plus), 6 (common) (see dwg. C-15245).

Power Check

1. Plug in the +15 volt power supply PC card (see dwg. B-14708) but leave all other PC boards out.
2. Turn power ON.
3. With a digital multimeter (DMM), check for +15 volts on the +15 volt power supply.
4. Check for proper starting of the chopper motor and source lamp.

WARNING: The light intensity from the quartz iodine lamp is intense and should not be looked at directly without special protective eyewear. Protective goggles with shaded lenses (Fed. Spec. #5) should be worn if it is necessary to look directly at the source.

Optical Alignment

This procedure is identical to the “Optical Alignment” section in Chapter 2. The object of optical alignment is to bring the optimum source energy to the detector. Generally the optimum energy will be the maximum amount of energy which can be focused on to the detector. This can be done by adjusting the various elements in the source module (see dwg. C-14628). See warning above.

Use a Variac on the input AC line to reduce the voltage and the lamp intensity to a tolerable level.

1. Vertical lamp position is achieved by loosening the screws of the base lamp bracket and moving the assembly up or down.

2. Horizontal position is achieved by loosening the Allen screw at the base of the lamp holder which allows side to side movement of the lamp.

3. Beam focusing is then achieved by loosening the lens holding bracket and moving the lens back and forth until the best focusing is obtained.

4. First visually optimize the lamp energy using a white piece of paper at various locations in the light path. Make adjustments as in Steps 1, 2, and 3 above.

5. Electronically optimize the energy as follows (the pre-amp must be installed in the detector compartment):

a. Insert an extender card in the switch driver and clamp position. Remove keys as necessary.
b. Connect an oscilloscope to pin 6 (video from pre-amp), and pin 3 (ground).
c. Remove the lens assembly from the light path.
d. Optimize lamp energy by adjusting the lamp position as described in steps 1 and 2 above.
e. Replace the lens assembly.
f. Focus the lamp as described in step 3 to give the maximum peak heights displayed on the oscilloscope.
g. If a Variac was used to alter the light intensity, disconnect it and reconnect source to power supply.

Component Selection

Each 514 is made for a specific application. Therefore each will have specifically selected electronic and optical components. These component values are selected per application by the Photometric department.

Measuring and Reference Optical Filters

The Photometric department will supply the optical filters; mount each filter in a filter holder (TAI P/N A1810) using 5-minute epoxy. Mount these optical filter assembly in the filter chopper wheel. The measuring filter is mounted on the edge of the chopper wheel with the white strip (see Fig. 5-1).

Proportional Temperature PCB

To fine tune temperature control, vary the resistance used by changing out resistor R2 in the three boards below, which use the same schematic (see dwg. B-15016).

Detector heater: R2
Space heater: R2
Sample heater: R2

Pre-Amp Gain

To select the gain, replace resistor R4 in schematic A-14619.

Log Card

One of three different types of log boards is selected, depending on the application. Replace the indicated resistors on the boards noted to adjust the logarithmic waveform.

Chopper-stabilized log PCB: R13 and R17 (See dwg. C-14586)
Log ratio PCB: R8 and R16 (See dwg. C-14907)
Dual log PCB: R13 and R17 (See dwg. C-17706)

E-to-I Converters

Analysis unit E-to-I (see dwg. B-14075):
0-0.5 volts in
10-20 mA out
R1 = 50 Ω (TAI P/N R262)

Control unit E-to-I (see dwg. B-16631): This is an optional card capable of providing the following outputs with 0-1 volt in and the listed values for R1:

1. 1 to 4 mA, R1 = 250 Ω
2. 4 to 20 mA, R1 = 63.5 Ω
3. 10 to 50 mA, R1 = 25 Ω

Alarm Comparator (Optional)

See dwg. B-14618.

Extended Voltage Amp

R3 is installed for outputs greater than 1 VDC (see dwg. A-14620).

I-to-E Converter

See dwg. A-14620.
Single Range: Strap point A to point B (see dwg. B-14454). R11 is not used for single range applications.
Dual Range: Strap C to I and D to T
Millivolt output (Optional): R8 and R9

Filter Position Sensor Adjustment

The filter position sensor is mounted in the detector condulet assembly (see dwg. C-14667). To adjust this sensor (power supplies installed):

1. Plug in the switch driver. Clamp the PCB into a card extender and insert into the detection module.
2. Loosen the sensor bracket mounting screw.
3. Attach an oscilloscope to circuit board connector, pin 8 of the switch driver PCB.
4. Adjust the sensor until the best sensor square wave is achieved. Refer to Table IV at the end of this chapter.
5. A further check will be done later under Automatic Gain Control.

Switch Driver and Clamp Circuit (B-14561)

Refer to Table IV at the end of this chapter. For the remainder of the adjustments in this section continue testing with the switch driver PCB attached to a card extender as described above.

1. Adjust the input square wave at pin 8 to be equal above and below ground. To accomplish this R2 must be raised or lowered in value. This is necessary for proper operation of the rest of the switching circuit.
2. Check the following test points for proper wave forms (refer to Table IV at the end of the chapter):
   a. TP4 (S). Square wave clamped to ground with +5V P-P.
   b. TP3 (S). Square wave clamped to ground with +5V P-P 180° out of phase with S.
   c. TP1 (P). Five (5) volt spikes with the tips at ground and the base line of +5V (5V P-P).
   d. TP2 (P). Same as TP1 (P) except 180° out of phase.
   e. TP5. Clamp reset pulse. 30V P-P spike centered around ground +15V and -15V.
   f. Remove the card extender and re-insert the switch driver card in the analyzer.

Balancing the Measuring and Reference Peak Heights

For the electronic checkout the peak heights are balanced with air in the sample cell. The peak heights will later be re-balanced with sample in the sample cell, prior to chemical calibration. The peaks must be balanced within +10% in air before the electronic calibration can be accurately completed.

1. Connect an oscilloscope to pin 6 on the circuit board connector of the switch driver PCB. The video from the pre-amp will displayed on the oscilloscope.

2. To determine which peak is the measuring or reference, connect another oscilloscope lead (use a dual trace scope) to TP3 on the switch drive PCB. The +5 volt (positive going) portion of the square wave will correspond to the measuring peak (see Table IV).

3. Screen the larger peak until about a +10% balance is achieved. Never screen both filters.

Automatic Gain Control (AGC) PCB

See dwg. B-14564. Insert the AGC in the detector module. Refer to Table IV for wave forms and test points (TPs).

1. TP1 (Violet): The clamped video should be between -0.4 to –2V P-P volts. The base line is clamped to ground. Screen the optical beam to achieve -0.4 to -2 volts P-P.
2. At this time set the gain of amplifier A1 to approximately 100. To accomplish this, it is necessary that the peak level detector PCB not be in place due to the fact that it is part of the AGC loop.
   a. Connect one lead of a dual trace oscilloscope to TP2 (gray), the other to TP3 (green).
   b. Set the attenuation so that the signal at TP2 is attenuated by a factor of 100 compared to the one at TP3.
   c. At this point you may note that the wave form at TP3 is saturated. To get it out of saturation simply place screens in the light path until a good trace is obtained.
   d. Adjust P1 until both wave forms are the same. (Note: actually 100 to 1)
3. Remove required screens in the light path to bring the voltage at TP1 (violet) back between -0.4 to -2 volts P-P. Install the peak level detector PCB. With the scope at TP3 of the AGC you should see the wave form come out of saturation due to AGC control.
4. Connect one input of the oscilloscope to TP5 on the Switch Driver and clamp. Connect other input to TP3 on AGC. The spike should be close to the halfway point between the negative going peaks at TP3. It does not have to be exact as long as it doesn't coincide with the signal. If the spike is off, move the filter wheel position sensor. If the spike falls on the signal it will clamp it to ground.
5. After adjusting the sensor recheck Section 1.6, Switch Driver and Clamp Circuit.

Peak Level Detector (PLD) PCB

Refer to Table IV.

1. With the oscilloscope leads at TP1 (red) and TP2 (blue) adjust R3 until the two wave forms are of equal size.

2. With an oscilloscope lead at TP3 (yellow), adjust R15 until the square wave is reduced to 20 mV P-P or less (best straight line).

3. Repeat step 2 with a scope lead at TP4 (orange) using R14 for adjustment.

4. Using a digital multimeter (DMM) at TP4 (orange) adjust P2 on the AGC PCB until 9 volts is obtained.

5. With the meter at TP3 (yellow) adjust R3 of the peak level detector until 9 volts is obtained.

6. Repeat steps 3 and 4 until both TP4 and TP3 read +9.0 VDC. This represents the zero absorbance condition.

Log Amplifier PCBs

One of three different types of log boards is selected, depending on the application. Insert the appropriate log PCB in the analyzer, using a card extender. The meter trim circuit adjustment (below) is common to all three log boards. The three sections after that describe individual log amplifier adjustments.

Meter Trim Circuit Adjustment

This adjustment calibrates the local meter so that its readings correlate with known voltages in from the peak level detector (PLD).

General Purpose Control Unit:

1. Set the power module control functions as follows: MEAS/REF to REF, NORM/ZERO to NORM.

2. Adjust the meter trimpot until the meter reads 90% of full scale. The meter trimpot on the chopper stabilized log amp (C-14586) and the log ratio board (C-14907) is R36, and on the adjustable log ratio board (C-14907) is R26.

3. Now turn the MEAS/REF switch to the MEAS position. The local meter should read 9 VDC if the PLD adjustments were properly done.

Explosion Proof Control Unit:

With the explosion proof units, the power module ZERO, REF, and MEAS levels, and the control unit meter readout for component of interest concentration all are read on the local meter.

1. Set the power module control functions as follows: NORM/REF to REF, NORM/MEAS to NORM and NORM/ZERO to NORM. The REF level is now displayed on the local meter.

2. Adjust the meter trimpot until the meter reads 90% of full scale. The meter trimpot or the chopper stabilized log amp (C-14586) and the log ratio board (C-14907) is R36, and on the adjustable log ratio board (C-14907) it is R26.

3. Now switch the NORM/REF to NORM and NORM/MEAS to MEAS. Meter should now read 9 volts if the PLD balance adjustments were properly done.

Log Ratio Amplifier Adjustments (dwg. C-14907):

When the log amplifier integrated circuit (A-1) is replaced on the log ratio amplifier circuit card, it is necessary to re-adjust potentiometers R7 and R9 in order to balance the circuit. To make the adjustments, the user must have an extender card, a 100KΩ resistor for connection between A1-2 and A1-7 (across C5), and a high impedance voltmeter to measure the voltage between A1-7 and connector pin 9. Proceed as follows:

1. Temporarily install a 100K resistor across A1-2 and A1-7 (across C5)
2. Disconnect connector pin 9 from 9 VDC by lifting a connection on the extender card. Connect pin 9 of printed circuit card to A1-1 (signal common).
3. Adjust R7 until the voltage measured at A1-7 is zero.
4. Remove 100K resistor from A1-2 and A1-7.
5. Reconnect connector pin 9 to 9 VDC.
6. Using a high impedance voltmeter to measure voltages at pins 7 and 9 of the card extender, adjust R3 on the peak detector circuit card until they are equal. With the reference and measuring voltages equal and at approximately 9 volts, adjust R9 of the log circuit card until the voltage at A1-10 is zero.
7. The log amplifier module (A-1) is now balanced..
8. The adjustment of R1 will be done during chemical calibration. This adjustment allows fine adjustment on the gain of A2, so that the output of A2 will be 0 to 0.4 VDC when zero and span fluids are passed through the analyzer.

9. Switch NORM/REF to REF. Adjust R36 to give 90% of scale on the analysis section meter.
10. Switch to MEAS. Meter should read 9 VDC.
11. Switch the NORM/ZERO switch to ZERO. Adjust the course ZERO so that the meter reads zero. The ZERO control should end up around 500.
12. The remainder of the adjustments on this PCB must be made in by TAI Photometric personnel.

Chopper Stabilized Log Amplifier

Refer to dwg. C-14586. When the log amplifier integrated circuit (A-1) is replaced on the chopper stabilized log amplifier circuit card, it is necessary to readjust potentiometers R10 and R11 in order to balance the circuit. In order to make the necessary adjustments, it is necessary to have an extender card, one 20KΩ resistor, and a high impedance voltmeter. Proceed as follows:

1. Use an extender card so that connections are accessible.
2. Temporarily connect a 20KΩ resistor (stable, not composition type, between A1-2 and A1-7 (across C2).
3. Unplug A2, A3 and A1.
4. Jumper A5-7 to A5-5 at socket and A2-3 to A2-6 at socket.
5. Install card in card extender and turn on analysis unit power.
6. Verify that voltage to pin 7 of the card edge connector is approximately 9 VDC (measure between pin 7 and pin 14).
7. Adjust potentiometer R10 until the voltage measured at A1-7 is zero with respect to signal common (TP3).
8. Remove jumpers installed in step 4.
9. Remove resistor connected in step 2.
10. Disconnect connector pin 7 from input by lifting a connection on the extender card.
11. Temporarily connect a 20K resistor between A5-7 and A5-15 to A1-16.
12. Jumper between A5-6 and A5-7 to provide the 9 VDC through 20K into A1-2 and through 20K into A1-16.

13. Adjust potentiometer R11 until the voltage measured at TP2 is zero.

14. The log amplifier integrated circuit A-1 should now be balanced.

15. Remove the 20K resistor and the jumper. Restore connections, replace IC's, turn on the instrument power, and check control loop by measuring voltage at the output of A2. Voltage should be -3 VDC, nominal.

16. If voltage is positive, R11 is out of balance or a component in the loop has failed. A slight adjustment of R11 (no more than 2 or 3 turns) should cause the voltage to change polarity to give the required negative voltage at pin 6 of A2.

17. Check pins 8 and 10 on amplifier A3 for presence of +5 volt square wave on the oscilloscope.

18. Switch NORM/REF to REF. Adjust R36 to give 90% of scale (9 VDC) on the analysis section meter.

19. Switch to MEAS. Meter should read 9 VDC.

20. Switch the NORM/ZERO switch to ZERO position. Adjust the coarse ZERO to cause the meter to read zero. The ZERO control should end up around 500.

21. The remainder of the adjustments on this PCB must be made by TAI Photometric personnel

Chopper Stabilized Adjustable Log Ratio Amplifier (Dual Log Board)

See dwg. C-17706. The dual log circuit is used when it becomes necessary to unequally balance the logarithmic waveform of the reference voltage and the logarithmic waveform of the measuring voltage so that an interfering, NIR absorbing, background compound can be cancelled out. When an interfering compound, in a three or more component mixture, absorbs more at the selected reference wavelength than it does at the measuring wavelength, the dual log PCB affords a means of balancing, and thereby cancelling, these inequalities. This type of compensation is only necessary in a three or more component mixture. It is not necessary where only two compounds are present.

1. When the adjustable log ratio board is used, disable the AGC circuit by removing A3 and A4 on the AGC board (B-14430).

2. When the log amplifier integrated circuit A1 is replaced on the chopper stabilized log amplifier circuit card, it is necessary to re-adjust potentiometers R10 and R11 in order to balance the circuit. You should have on hand an extender card to help make connections accessible, one 20K ohm resistor, and a high impedance voltmeter.
    a. Temporarily connect a 20K resistor (stable, not composition type) between A1-2 and A1-7, across C2.
    b. Unplug A2, A3, A5, and A9.
    c. Jumper A5-7 to A5-5 at the socket and A2-3 to A2-6 at the socket.
    d. Install the card in the card extender and turn on the analysis unit power.
    e. Verify that voltage to pin 7 of the card edge connector is approximately 9 volts. Measure between pin 7 and pin 14.
    f. Adjust potentiometer R10 until the voltage measured at A1-7 is zero with respect to signal common TP3
    g. Remove jumpers installed in step c.
    h. Remove resistor connected in step a.
    i. Set R34 to give 9 volts on A9-6. Also set R34 to give 9 volts on A9-14.
    j. Remove Q1 from its socket.
    k. Disconnect connector pin 7 from input by lifting a connection on the extender card.
    l. Temporarily connect a 20K resistor between A5-7 and A5-15 to A1-16.
    m. Jumper between A9-6 and A5-7 to provide the 9 VDC through 20K into A1-2 and through 20K into A1-16.
    n. Adjust potentiometer R11 until the voltage measured at TP2 is zero.
    o. The log amplifier integrated circuit A-1 is now balanced.
    p. Remove the 20K resistor and the jumper. Restore connections and replace IC's. Turn on the instrument power and check the control loop by measuring voltage at the output of A2. Voltage should be -3 VDC, nominal.
    q. If voltage is positive, R11 is out of balance or a component in the loop has failed. A slight adjustment of R11 should cause the voltage to change polarity. After checking this go back to the nominal -3 VDC by adjusting R11.

r. Check pins 8 and 10 on amplifier A3 for presence of +5 volt square wave on scope.
s. Switch NORM/REF to REF. Adjust R36 to give 90% of scale (9 VDC) on the analysis section meter.
t. Switch to MEAS. Meter should read 9 volts.
u. Switch the NORM/ZERO switch to ZERO position. Adjust the coarse ZERO to cause the meter to read zero. The ZERO control should end up around 500.
v. The remainder of the adjustments on this PCB must be made by TAI Photometric personnel

E-to-I Converter for Analysis Unit

Refer to dwg. B-14075. This unit will have 10 to 20 mA output, with 0 to 0.5 volts input. This means when operating at the recommended range of 0 to 0.4 volts from the log PCB, the output from E-to-I PCB will be 10 to 18 mA.

1. Insert this board in the analyzer using a card extender.

2. Adjust the coarse ZERO control, on the power module, for zero volts into the E-to-I converter. Measure this voltage with a DMM at TP1 (red) on the log board or at pin 6 of the E-to-I circuit board connector.

3. Adjust R7 to give 10 mA output between pins 1 and 13.

4. Adjust the coarse ZERO control to give 0.5 volts in at pin 6. In some cases you may not be able to adjust from 0 to 0.5 volts. Since the E-to-I board gives a linear current output with voltage, the following formula can be used to calculate the current output (I out) in mA relative to voltage in (V in)

$$I\ out = 20\ (V\ in) + 10mA$$

5. Adjust R12 to obtain 20 mA or the appropriate output determined in step 4 between pins 1 and 13.

6. Repeat steps 2 through 5 until the results are reproducible.

Note: This card is the last PCB located in the detector condulet.

Proportional Heater PCBs

See dwg. B-15016. There are three proportional heat PCBs, all of which are located in the power module.

1. There are no adjustments on this card other than the installation of R2 per desired temperature regulation (see section 5.×: Component Selection). The type and value of thermistor used is necessary for proper selection of R2.
2. There are two ways of testing the controlling action of the PCBs. The first is a preliminary test on the board. The second tests the performance of the board in the 514 analyzer.
    a. Test the heater PCB in the “heater card test jig” in TAI’s quality control area. A potentiometer on the test jig will simulate the thermistor resistance. As this pot is varied, the lamp (simulating the analyzer heater) will turn on and off.
    b. Place the PCBs in their normal positions in the analyzer power module. Connect a 100V neon lamp between the case of Q1 and the positive side of C1, or across the heaters. When the heater has reached temperature equilibrium the lamp will blink on and off at a rapid rate (fraction of a second) indicating proper proportional control. A slow blink rate (several seconds) indicates ON/OFF heat control, but improper proportional control.

Control Unit

Power Supply, +15 Volts.

To check the control unit power supply, plug in control unit +15 volt power supply and check for +15 volts.

I-to-E Converter

See dwg. A-14620. This card has no calibration adjustments, so all that can be checked is proper operation at the output of A2 (circuit board pin 15), which is 0-1 volt out for an input of 10-20 mA at circuit board pin 14.

Extended Voltage Amplifier

See dwg. B-16221. To adjust the offset voltage of Q1:

1. Remove the I-to-E converter.
2. With zero volts into pin 2 install a meter at the output of Q1.
3. Adjust R1 for zero offset at the output of Q1.
4. Reinstall the I-to-E board.

Meter Trim & Output Voltage Calibration

For localized explosion-proof control modules, the trim calibration is done as in the “Meter Trim Circuit Adjustment” section under Log Amplifier PCBs.

For the General Purpose Control Unit Models:

1. Place a DMM on the output pin 6, on Q1 or circuit board connector pins. Set the SPAN setting to 250 or higher.
2. Adjust the coarse ZERO potentiometer on the power module to give zero volts on the DMM. The control unit meter should read zero.
3. Adjust the coarse ZERO potentiometer to give the full scale output voltage on the DMM (generally 1.00 volt). If the 0-1 volt adjustment cannot be made with the coarse ZERO, increase the span control setting.
4. Once the instrument is set for the proper output voltage, adjust R5 to make the control unit meter read exactly 100% of full scale. Check a few points in between 0 and 100% to see if the output tracks with meter reading in a linear fashion.

Control Unit Options

E-to-I Converter

See dwg. B-16631.

1. Install R1 per current output desire (see “Control Unit E-to-I” under Component Selection). With zero volts in adjust R7 until the desired lower current output level is obtained.

2. Change the input voltage to 1 volt. Adjust R12 until the upper current level is achieved.

3. Repeat 1 and 2 until repeatability is achieved.

Alarm Comparators, Single and Dual

See dwg. B-14718.

1. PCB strappings (jumper wires) for set point alarm actuation are as follows:

   Dual: Above-Above: A to F & E, B to G, C to D
   Dual: Below-Below: A to G & D, B to F, C to E
   Dual: Above-Below: A to F & D, B to G, C to E
   Dual: Below-Above: A to G & E, B to F, C to D
   Single: Below: A to G, B to F
   Single: Above: A to F, B to G

2. Single Alarm PCB: Adjust R2 until 1 volt is obtained at the full clockwise position of P2 (setting of 1000). If the instrument output of the alarm is set for 1 volt full scale the alarm is set for 1 volt full scale. The alarm relay should activate or deactivate within +2% of the P2 dial setting.

3. Dual Alarm PCB: Same as above, except both relays should activate or deactivate within +2% of P2 and P3 dial settings.

Photometric Laboratory Calibration Procedure

1. Connect a recorder to the control unit.
2. Remove any screens placed over the sample cell that are in the optical path.
3. Bolt cover on sample compartment.
4. Remove main cover from detector module to gain access to test points.
5. Make certain proper optical filters are in place.
6. Small detector compartment covers must be in place.
7. Turn on analyzer and recorder.
8. With an oscilloscope, check all sync. pulses on the switch driver and clamp circuit (refer to Table IV at the end of this chapter).
9. Wait one hour for warm-up.
10. Flow zero fluid into the sample cell. Lock in place. Zero fluid is the background fluid with a minimum amount of the component being measured.
11. With an oscilloscope, check the waveform at TP1 (violet). Balance measure and reference peaks heights within 20%. The clamped video should be between -0.4 to -2 volts P-P. The base line is clamped to ground. Change the preamplifier gain resistor, R4, to obtain -0.4 to -2 volts P-P, if necessary.
12. Connect one lead of a dual trace oscilloscope to TP2 (gray), the other to TP3 (green).
13. On the peak level detector PCB connect a DMM to TP4 (orange) and ground (any black test point). Adjust P2 on the automatic gain control PCB until 9.00 volts are obtained.
14. With the meter at TP3 (yellow) adjust R3 on the PLD until the calculated voltage is obtained. Some calculations will have to be made to properly calibrate the analyzer when the zero fluid is not exactly zero for the component of interest. When the zero fluid is zero for the component of interest the PLD voltage at TP3 is set

to 9.00 volts. When the zero fluid concentration (C_z) is some other value, proceed as follows:

Estimate the absorbance change (A_{fs}) expected for full scale changes in concentration. Then from the concentration of the component of interest in the zero fluid (C_z) and the full scale meter reading (M_{fs}) calculate the voltage setting at TP3 for the zero fluid (V_z).

$$\log_9 (V_z) = -(A_{fs}) \frac{C_z}{M_{fs}}$$

Example: If A_{fs} = 1 unit
M_{fs} = 10%
C_z = 1%

Then:

$$\log_9 V_z = -(1)\frac{(1)}{10}$$

$$10^{\log_9 V_z} = 10^{-.1}$$

$$V_z = (9)(0.79) = 7.15 \text{ volts}$$

15. On the chopper stabilized log board place a DMM at TP1 (red). Adjust the coarse ZERO control on the analysis unit to give an output equal to $(C_z/C_{fs})(V_{fs})$. V_{fs} equals the voltage output from the chopper stabilized log board for a full scale deflection, which equals 400 mV. For example, if:

    C_z = 1%
    C_{fs} = 10%

    then the voltage output at TP1 will equal

    $$(1/10)(400 \text{ mV}) = 40 \text{ mV}.$$

16. Set the span control on the control unit to 500.

17. Adjust the fine ZERO control on the control unit to give a meter reading equal to C_z.

18. Re-check the peak voltages on the switch driver and clamp circuit at TP1 (violet). If the peaks have increased, it is probably due to outgassing in the sample cell caused by improperly locked-in sample, or by a leak in the system. Correct the problem and repeat steps 10 thru 20.

19. Fill the sample cell with span fluid. Turn unit off, remove chopper stabilized log board and place it on an extender board. Turn the unit back on and adjust R16 on the chopper stabilized log board to give a voltage at TP1 (red) equal to:

$$\frac{(C_s - C_z)\,V_{fs}}{M_{fs}}$$

where V_{fs} is the voltage output from TP1 for full scale deflection, which equals 400 mV.

Example: If $C_s = 8\%$
$C_z = 1\%$
$M_{fs} = 10\%$

Then:

$$\text{Voltage output at TP1} = \frac{8-1\,(400\text{ mV})}{10} = 280\text{ mV}$$

Set the SPAN control (on the control module) to give a meter reading of

$$C_s - C_z$$

20. Adjust the coarse ZERO control on the analysis unit until the voltage at TP1 (red) is equal to:

$$(C_s/M_{fs})V_{fs}$$

21. Record the following data:

a. VDC on PLD, TP3 and TP4
b. VDC on chopper stabilized log operator, TP1 (red)
c. AC P-P on chopper stabilized log operator, TP2 (yellow)
d. AC P-P on automatic gain control PCB TP1 (violet)
e. Control unit meter readout.

22. An oscilloscope on TP2 (yellow) will display a 400 Hz square wave. If this peak-to-peak voltage is less than 100 mV, decrease the value of R13 (which will be 1KΩ for most applications). If the P-P voltage is greater than 0.4 volts, increase the value of R13. If the voltage is still above 0.4 volts, the cell spacer must be decreased, or other optical filters selected.

23. With a DMM on the log PCB TP1 (red) record VDC. If it is below 0.2 volts, adjust R16; increase R17 if you run out of adjustment with R16. If the voltage is higher than 0.4 volts,

adjust R16; decrease R17 if you run out of adjustment with R16. The actual limit is 0.5 volts, with 0.4 volts giving some leeway. The log circuit will give accurate results for much higher voltage (as high as 4 volts), but the next stage (E-to-I) will not be accurate above 0.5 volts in.

24. As a check go back to the zero fluid. The meter should read the correct zero fluid concentration. Record the data points as in step 23.

25. Lock zero fluid in the sample cell. Run overnight stability. Visually inspect the sample cell for bubbles, indicating sample outgassing and cell leakage. Stability can also be run by removing the liquid from the sample cell, and drying out the cell with acetone followed by dry nitrogen or air purging. Screen the optical path to obtain the same P-P voltages (as when liquid was in the cell) at TP1 (violet) on the automatic gain control PCB. Purge with dry gas continuously.

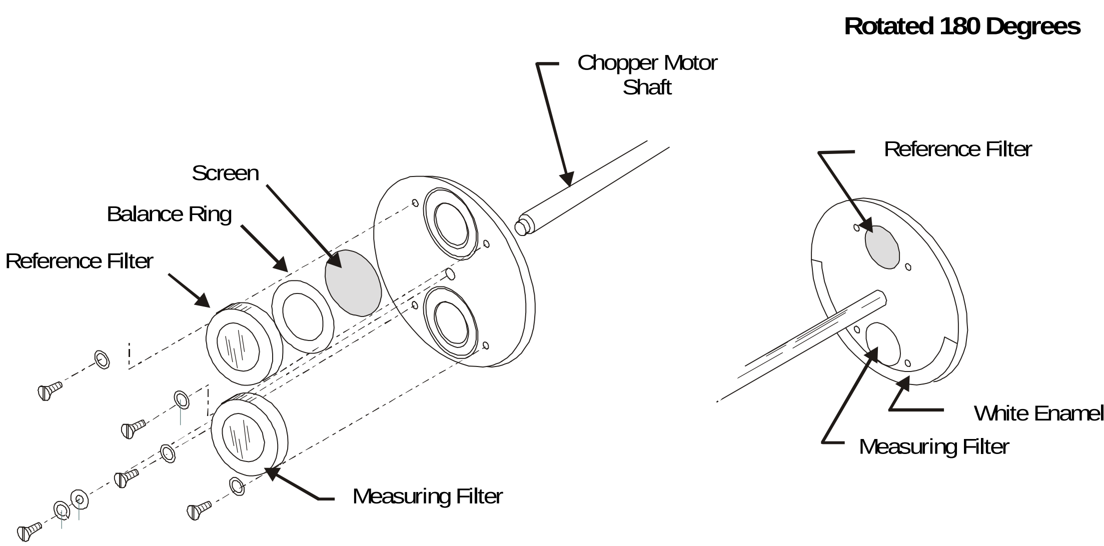


Figure 5-1. Filter Wheel - Exploded View

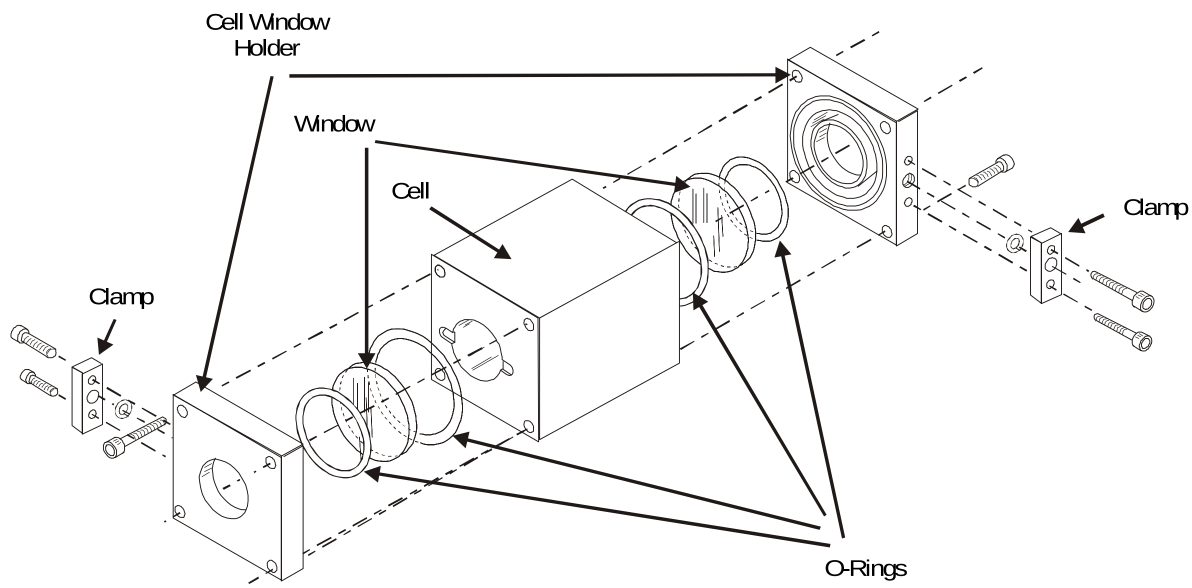


Figure 5-2. Sample Cell - Exploded View

Appendix

Specifications

Accuracy:	±2% full scale or better
Reproducibility:	±1% full scale or better
Noise:	Less than ±1%
Drift:	Less than 1% per day
Diurnal:	Less than 1% per day
Sensitivity:	0.02 to 1.5 absorbance units
Electronic Response:	90% in 10 seconds
Light Source:	Quartz iodine lamp
Filter Wavelengths:	1.0 to 2.8 microns
Sample Cell:	Stainless steel with sapphire windows, standard; others available; length per application
Flow Rate:	Typically 50-200 cc/min. (depending upon application)
Ambient Temperature:	0° to 50° C (without available auxiliary heating).
Electrical Requirements:	115 VAC, 60 Hz (standard)
Readout Device:	Meter on control module
Analog Output Signal:	0-1 V (standard)

Options Designated by Model # Suffix

B1:	Local Explosion Proof Control Unit
B2:	Remote Explosion-proof Control Unit
I5, I20 or I50:	Current Outputs
S1 or S2:	One or Two Alarm Circuits
K5, K10 or K100:	Millivolt Output Signals
E5 or E10:	Voltage Outputs in lieu of 0 to 1 V output
D:	Dual Range
A:	Automatic Zero
O5, O20 or O50:	Optically Isolated Current Outputs (explosion-proof control unit only)

Specific Application Data

Statistics

Customer Order No.: ______________________

TAI Sales Order No.: ______________________

Equipment Model Nos.: ______________________

Analyzer: ______________________

System: ______________________

Analyzer Serial No.: ______________________

Analysis

Component of Interest: ______________________

Range 1: ____________ Range 2: ________

Background: ______________________

Start-up ZERO setting: __ Coarse ________ Fine ________

Start-up SPAN setting: ______________________

Noise: ______ Linearity: ______ Diurnal: ____

Optics

Source: ______________________

Measuring Cell

Length: ______________________

Materials

Spacer: ______________________

O-Ring: ______________________

Windows: ______________________

Temperature

Preheater: ______ °C Space Heater: ______ °C

Optical Filters:

Measuring Wavelength: ______ μ, 1/2 BW ______ TAI #: ____

Reference Wavelength: ______ μ, 1/2 BW ______ TAI #: ____

Detector Type: ______________________

Detector Compartment Temperature: ______ °C

Meter Dial Marking: ______________________

Output Signals: ______ mV ______ V ______ I

______ Iso I

Alarms:

Mode: Relays energized above or below setpoint

	ABOVE	BELOW
No. 1		
No. 2		

Drawing List

Circuit Connection Drawings

Source Module	A-14704
Sample Module	A-14703
Detector Module	C-14581
Power Module (for Explosion-Proof Control Unit)	C-14746
Power Module (for General Purpose Control Unit)	C-14731
Control Module (Explosion Proof)	C-15829
	C-15695
Control Module (General Purpose)	C-14691

Outline Drawings

Analysis Unit w/Explosion-Proof Control Unit	D-18308
General Purpose Control Unit	C-16801
Analysis Unit	D-18307
Source Module Assembly	C-14628
Sample Module Assembly	C-17356
Detector Module Assembly	D-14665
Detector Box Subassembly	C-14667
Analyzer System Outline w/Integral Explosion-Proof Control Unit	C-15644
Analysis Unit Outline	C-18313
Control Unit Outline General Purpose	B-15066

Electrical-Power Module

Proportional Temperature Controller Sch.	B-15016
Proportional Temperature Controller Assy.	B-14449

Electrical-Control Module

I-to-E Converter Sch.	A-14620
I-to-E Converter Assy.	B-14454
Alarm Comparator Sch.	B-14718
Alarm Comparator Assy.	A-9309
Extended Voltage Amplifier Sch.	B-16221
Extended Voltage Amplifier Assy.	A-15163
E-to-I Converter Sch.	B-16631
E-to-I Converter Assy.	B-14702
Auto Zero/Ext. Voltage Ampl. Sch.	B-14729
Automatic Zero Assy.	A-16888

Drawing List, Continued

Electrical-Detector Module	
Preamplifier Sch.	A-14619
Preamplifier Assy.	A-14505
Switch Driver and Clamp Sch.	B-14561
Switch Driver and Clamp Assy.	B-14434
Automatic Gain Control (AGC) Sch.	B-14564
Automatic Gain Control (AGC) Assy.	B-14430
Peak Level Detector, Sample and Hold Sch.	B-14554
Peak Level Detector, Sample and Hold Assy.	B-14441
Chopper-Stabilized Log Amplifier Sch.	C-14586
Chopper-Stabilized Log Amplifier Assy.	B-14579
Log Ratio Amplifier Sch.	C-14907
Log Ratio Amplifier Assy.	B-14083
E-to-I Converter Sch.	B-14075
E-to-I Converter Assy.	B-14453
Electrical-Power Supply	
Regulated Power Supply Sch.	B-14708
Regulated Power Supply Assy.	A-9306
Interconnection Diagrams	
Analyzer System (w/Explosion-Proof Control Unit)	B-16571
Analyzer System (w/General Purpose Control Unit)	C-15245

Spare Parts List

QTY	P/N	DESCRIPTION
Power Condulet Assembly		
5	F11	Fuse, 5 A
3	B14449	Printed Circuit Card Assembly, Temperature Controller
Control Unit Assembly		
1	A9306	Printed Circuit Card Assembly, Power Supply
1	B14454	Printed Circuit Card Assembly, I/E Converter
1	A9309	Printed Circuit Card Assembly, Alarm Comparator (if equipped with alarm option)
1	B14702	Printed Circuit Card Assembly, E/I Converter (if equipped with current output option)

1	A16888	Printed Circuit Card Assembly, Auto Zero/Meter Driver (if equipped with automatic zero)
1	A15163	Printed Circuit Card Assembly, Extended Voltage Amplifier (if not equipped with automatic zero)
1	O84	Optically Isolated E/I Converter Assembly (Explosion Proof only)
5	F11	Fuse, 5 A

Detector Condulet Assembly

1	A9306	Printed Circuit Card Assembly, Power Supply
1	B14430	Printed Circuit Card Assembly, AGC
1	B14434	Printed Circuit Card Assembly, Switch Driver
1	B14441	Printed Circuit Card Assembly, Peak Level Detector
1	B14453	Printed Circuit Card Assembly, E/I Converter
1	B14083	Printed Circuit Card Assembly, Log Ratio Module
	or	
1	B14579	Printed Circuit Card Assembly, Chopper Stabilized Log Amplifier
1	S239	Filter Position Sensor
1	T174	Thermistor
1	B14668	Detector Cell Assembly
1	A14505	Printed Circuit Card Assembly, Preamplifier
1	D60976	Power Supply Assembly

A minimum charge is applicable to spare parts orders.

IMPORTANT: Orders for replacement parts should include the part number and the model and serial number of the system for which the parts are intended.

Send orders to:
TELEDYNE ANALYTICAL INSTRUMENTS
16830 Chestnut Street
City of Industry, CA 91749-1580
Telephone: (626) 934-1500
TWX: (910) 584-1887 TDYANYL COID
FAX: (626) 961-2538
Web: www.teledyne-ai.com
or your local representative