SECTION IV. THEORY OF OPERATION

9.4.1 **INTRODUCTION**

This section provides a detailed explanation of how the CT12K ceilometer functions to detect clouds, calculate their heights, and report the results. The operating theory is presented on two levels. The first level describes the principles of operation for the ceilometer and identifies the basic functional areas on a block diagram level. The second level describes the individual functional areas to a level of detail that enables isolation of a faulty field replaceable unit (FRU).

9.4.2 **SIMPLIFIED BLOCK DIAGRAM DESCRIPTION**

The following paragraphs describe the basic operation of the ceilometer and the basic physical principles used by the ceilometer during operation. A simplified block diagram including the ceilometer components is also provided to describe the basic system configuration and operation sequences.

9.4.2.1 **Principles of Operation**. The CT12K ceilometer operating principles are based on measuring the amount of time it takes a pulse of light to travel from the ceilometer transmitter through the atmosphere, reflect off a cloud, and return to the ceilometer receiver. By starting a timer when the transmitter outputs a pulse of light and stopping the timer when the receiver detects the reflected pulse return, the distance traveled by the pulse (at the speed of light) can be calculated. Because the total distance traveled includes a path from the transmitter to the cloud and back again, the actual height of the cloud (from the transmitter) is actually one-half of the total distance. The calculation can be expressed as: $h = ct/2$

where: h = Height of cloud

c = Speed of light (9.8356×10^8 feet/second)

t = Time from transmission to reception

Example: Cloud return detected 24.4 microseconds (μs) after transmission indicates a cloud at 12,000 ft.

In practical application, particles in the atmosphere reflect and scatter the transmitted light pulse. These particles (dust, smoke, or water droplets) have a degrading effect on the reception of the light pulse. However, these effects can also be useful in detecting the presence of fog or precipitation. Therefore, the signals transmitted and received are related as depicted on figure 9.4.1. The ceilometer compensates for the attenuation effects on the pulse due to particles in the atmosphere to minimize their influence. The CT12K ceilometer samples the return signal at a 100-nanosecond rate to cover a time frame of 25.4 μs. As a result, the ceilometer is able to detect clouds up to a height of 12,500 feet with a 50-foot resolution. This resolution is considered adequate since visibility within the densest clouds is on the order of 50 feet.

For safety and economic reasons, the laser power used by the ceilometer is so low that components of ambient light (noise) typically exceed the laser light pulse received at the ceilometer receiver. To overcome this problem, the ceilometer uses several transmission/reception cycles in its measurements and sums the results. As a result of this technique, the actual pulse return is strengthened in detection (because it is relatively constant), while the noise tends to cancel itself out (because it is random in nature). This concept is illustrated on figure 9.4.2, which shows three separate transmission and reception cycles. Sample 1 provides a relatively clean return, with the majority of the received signal due to the cloud return. Sample 2 provides a noisy return, where the cloud return is virtually indistinguishable from the noise. Sample 3 provides a moderate noise level, where the cloud return is presented amidst the noise. The sum of these three samples results in a significantly higher return signal level over only one range of time. This distinction in the sum is produced due to the cloud return component present in each sample as compared to the noise component, which varied in each sample. Compensations such as this are also applied to the samples to filter out returns due to other obstructions in the light pulse path.

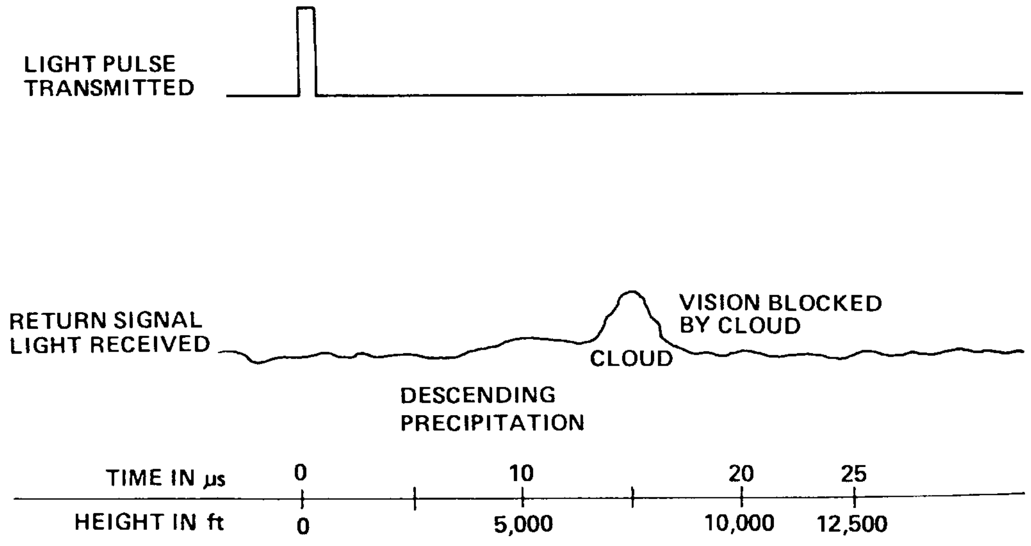

Figure 9.4.1. Ceilometer Laser Transmission/Reception Cycle

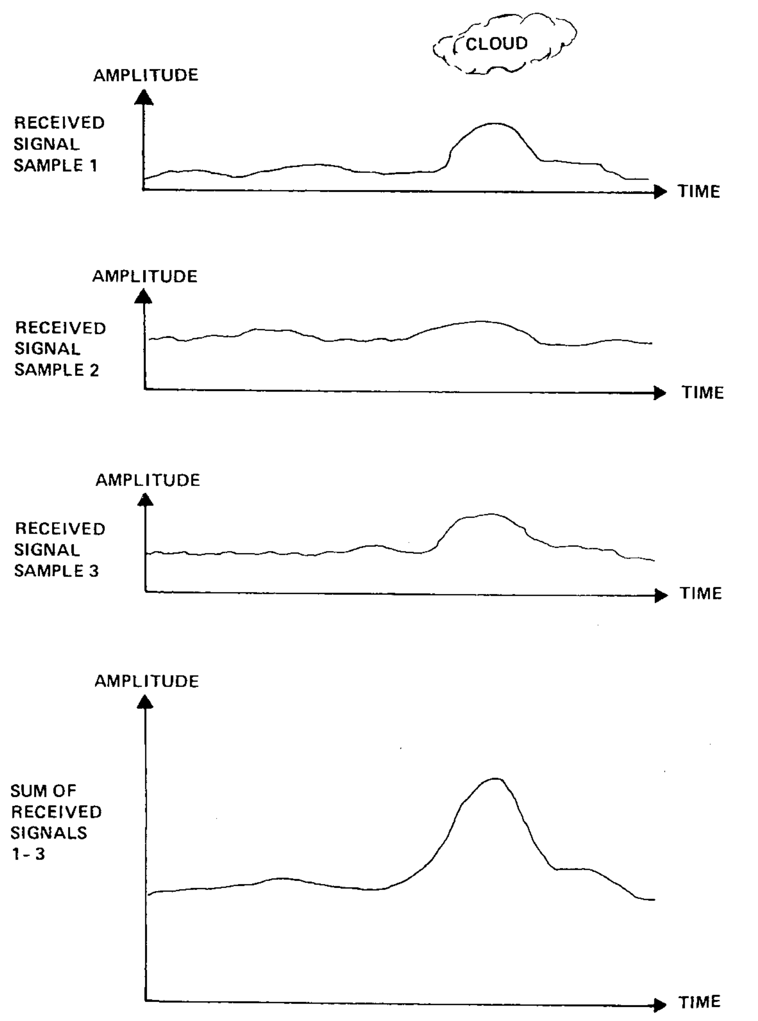

Figure 9.4.2. Received Signal Sampling Noise Cancellation

9.4.2.2 **Simplified Block Diagram Description**. A simplified block diagram of the CT12K ceilometer is provided on figure 9.4.3. The operation of the ceilometer is basically performed by seven functional areas: the measurement circuit, output interfaces, internal temperature control, internal monitoring, power supply section, window conditioner, and solar shutter option.

9.4.2.2.1 **Measurement Circuit**. The measurement circuit is the main operational part of the ceilometer and functions to actually measure the atmosphere. The measurement circuit involves the processor, its operational software, and its memory. The processor begins a measurement cycle by signaling the laser sequence control to issue a laser trigger pulse. The pulse frequency and duration are also specified. The laser transmitter executes the trigger signal to force a laser diode to emit a short, high intensity pulse of infrared single-wave radiation. The laser pulse is focused through the transmitter optics to produce a parallel beam. The laser power monitor senses the emitted laser pulse as it leaves the enclosure and outputs a voltage signal (back to the processor) that is proportional to the average power level of the laser. The emitted laser pulse then travels through the atmosphere and small amounts of the radiation are backscattered by any non-gaseous particles in the atmosphere. The reflected signals are then detected by the receiver.

The receiver optics are designed to focus the incoming light onto a silicon avalanche photodiode. Because only the wavelength of the transmitted pulse (904 nanometers (nm)) is needed, a filter built into the receiver circuit blocks out the majority of the extraneous signals. The photodiode converts the light signals into a small electrical current. The preamplifier in the receiver circuit converts this current into a larger voltage signal for easier processing by the system. Data acquisition circuitry in the measurement function contains another amplifier, an analog to digital (A/D) converter, and a sample accumulator circuit. At the same moment that the transmitter emits a pulse, the data acquisition circuit is initialized to start sampling the received light. The received light is converted to an electrical voltage signal by the receiver and sampled by the A/D converter to produce a digital value. This digital value is then stored in the sample accumulator and the next sample is processed. As a result, a digitized sample of incoming light is stored in memory every 100 nanoseconds for 25.4 μs (254 total samples). This represents backscattered returns from 0 to 12,650 feet in the atmosphere, with each sample resulting from returns 50 feet above the previous return.

As described in the principles of operation, the received light signal is typically buried within noise signals. The noise effects, due to their random nature, can be overcome by taking multiple samples and summing them. Hence, the ceilometer emits several pulses to conduct its sampling. Before the second pulse (and all successive pulses) are transmitted, the digitized sample results from the previous transmission are stored in a sample summing memory circuit. When the next pulse is transmitted, the received signals are digitized as before and stored in the sample memory. When all 254 samples are stored, they are added to the contents in the sample summing memory to accumulate the results. This process continues until the desired number of pulses (as directed by the processor) have been processed. Typically, the number of samples taken falls into the number of thousands. For example, 10,000 pulses can be processed and accumulated to provide results that permit separation of cloud signal returns from noise. Statistically, this results in providing signal returns from clouds that are approximately 100 times stronger than the noise level, and thus easily discerned. After the sampling, digitizing, and summing process, the summing memory contains the raw profile of the atmosphere. The data are then transferred to the processor memory and the sample accumulator is cleared to begin the next acquisition cycle.

Before the next acquisition cycle begins, the processor uses the A/D converter to check the average laser power measured by the laser power monitor during the transmission cycle. Based on the laser power value measured, the processor calculates a new value for the pulse frequency to adjust the average laser power as close as possible to the optimum value. Average laser power is thus controlled automatically by adjusting the pulse repetition rate. In addition, before the next acquisition cycle, the processor checks the measurement signal and noise levels and selects the gain to be used for the next cycle. High gain is desirable, but the active resolution range of the A/D converter must not be exceeded. The processor then starts a new measurement cycle and begins to process the raw data just accumulated to construct the cloud data for report to the DCP.

9.4.2.2.2 **Output Interfaces**. The CT12K ceilometer provides two different output interfaces. An RS-232C interface is the primary interface used on the ceilometer for both sensor reporting and maintenance purposes. The ASOS configuration for the ceilometer adds a fiberoptic modem module interfaced to the RS-232C interface to provide the fiberoptic data link with the DCP.

9.4.2.2.3 **Internal Temperature Control**. The internal temperature of the ceilometer cabinet is controlled by two heaters in the cabinet. The two heaters are connected to control circuitry that enables one of three possible configurations depending on the heating requirements of the cabinet. The temperature controller monitors the ceilometer internal air temperature and generates a corresponding voltage level. This voltage level is applied to voltage comparators that are set for reference voltages equal to 32 degrees Fahrenheit (°F) (0 degrees Celsius (°C)) and 68°F (20°C). The output of the comparators drives relays that apply power to the heaters. When the air temperature is above 68°F, power is removed from both heaters. When the temperature is between 32°F and 68°F, the heaters are powered and configured in series, providing approximately 20 watts of heating power. When the temperature falls below 32°F, the heaters are powered and configured in parallel, providing approximately 80 watts of heating power. Without heating, the cabinet internal temperature is typically 10°F to 20°F above the ambient temperature. With full heating, the cabinet internal temperature is typically 40°F to 60°F above the ambient temperature.

9.4.2.2.4 **Internal Monitoring**. Internal monitoring consists of the circuitry required to monitor voltage levels and signals produced by the ceilometer during normal operation. The analog monitoring section includes a signal selector and an A/D converter. The signal selector is used to select which of the input voltage signals is applied to the A/D converter. The A/D converter processes the selected analog voltage to produce a digital data value. This data value is then applied to the processor for analysis to detect malfunctioning assemblies and components.

9.4.2.2.5 **Power Supply Section**. The power supply section consists of a high voltage power supply and an unregulated power supply that provide the unregulated power to all of the electronics assemblies in the ceilometer. All of the assemblies are provided with local voltage regulators. The temperature control transformer is used to provide the power required by the cabinet heaters.

9.4.2.2.6 **Window Conditioner**. The window conditioner consists of a heater and blower that provide warm airflow across the optics windows of the ceilometer. This airflow keeps the windows clean and dry and permits optimum performance of the system. A temperature sensor in the window conditioner monitors the operation of both the heater and the blower and reports to the internal monitoring circuit. For safety considerations, the heater is provided with a thermostat that is set to remove power if the temperature reaches 250°F (120°C).

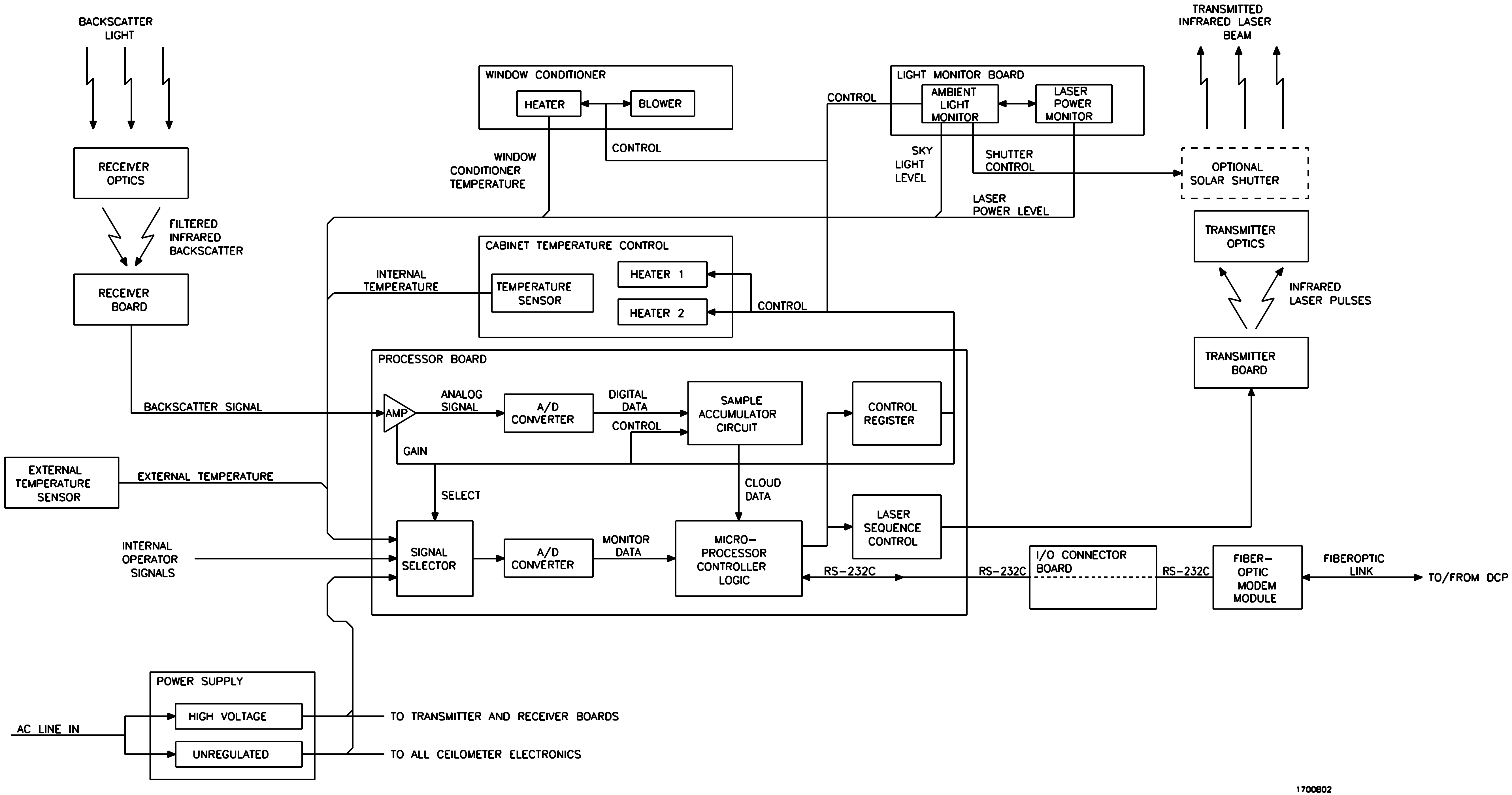

Figure 9.4.3. Ceilometer, Simplified Block Diagram

9.4.2.2.7 **Solar Shutter Option**. The solar shutter is an optional assembly to the CT12K ceilometer. It is installed on ceilometers located in the region of 30 degrees North latitude to 30 degrees South latitude to protect the transmit laser from the effects of direct sunlight. A tropical receiver board (part No. 62828-90112-11) is installed in ceilometers that are equipped with the solar shutter assembly (table 9.1.2). The tropical receiver board has a different filter and mounting block than the receiver board filter used on ceilometers without a solar shutter. The solar shutter closes during periods when direct sunlight can enter the transmitter lens system and when a laser pulse is not being transmitted. The solar shutter assembly consists of a control solenoid and a flap that are located above the transmitter and a light sensor and electronics that are installed on the light monitor board. The light sensor and control electronics determine when the shutter should be shut and activate the solenoid to move the shutter.

9.4.2.2.8 **Snow Radiation Shield Option**. The snow radiation shield is an optional assembly to the CT12K ceilometer. It is installed on ceilometers that are susceptible to having their external ambient air temperature sensors inadvertently heated by snow reflected solar radiation. The snow radiation shield consists of stainless steel plating bent into a rectangular box shape with the short sides left open to allow for airflow into the resultant enclosure. The snow radiation shield is painted white to reflect solar radiation. Figure 9.1.2 shows the snow radiation shield in place. Table 9.5.33 contains installation and removal procedures for the snow radiation shield.

9.4.3 DETAILED BLOCK DIAGRAM DESCRIPTION

9.4.3.1 **Introduction**. The ceilometer is composed of two basic subsystems: the optics subsystem and the electronics subsystem. The optics subsystem consists of the windows and lenses required for laser transmission and light energy reception. The optics subsystem supports several separate, but interrelated, electronics assemblies. A detailed block diagram of these assemblies is illustrated on figure 9.4.4 and described in the following paragraphs.

9.4.3.2 **Processor Board**. Processor Board A1 is the main control circuit for the ceilometer. The processor board is a microprocessor-based design that performs all of the following functions:

a. Provides software-controlled laser pulse triggering.

b. Buffers and amplifies (software-controlled gain) backscatter reflections sensed by the receiver board.

c. Samples, converts, and stores amplified echo signals.

d. Processes the stored echo signal data to calculate cloud base levels and other relevant atmospheric information.

e. Transfers data and commands through the onboard RS-232C serial interface.

f. Monitors unregulated power supply voltages, transmitter and receiver board operating voltages, laser power level, ambient light level, and operating temperatures throughout the ceilometer.

g. Controls the operation of the window conditioner and the optional solar shutter via the light monitor board.

h. Automatically controls internal heating of the ceilometer.

The electrical power required by the processor board is derived from dc power inputs provided by the unregulated power supply board. Voltage regulator circuits on the processor board stabilize these dc power inputs for use by the processor board electronics. In addition, some of these regulated voltages are output by the processor board for application to the I/O connector board. Several onboard precision voltage references are also derived for measurement needs by circuits on the processor board.

The main data processing is performed by the central processing unit (CPU) and its related control logic. The operating system and programmed instruction set are stored in erasable programmable read-only memory (EPROM) for use by the CPU. A section of random access memory (RAM) provides the CPU with data workspace and temporary data storage. Onboard EEPROM is used for nonvolatile data storage for ceilometer scaling factors and other important parameters.

Through an integral asynchronous communications port, the processor board maintains serial data communications with the DCP. System timing sequences are also maintained onboard, with a special watchdog timer provided to force system resets in the event of a temporary processor hangup. Two light emitting diodes (LED's) on the processor board indicate the operating status of the CPU. A green LED flashes at an approximate 1-second interval to indicate that the system is operating normally. A red LED illuminates when the CPU is in a reset condition.

The primary function of the processor board is to initiate laser transmissions, collect the reflected cloud echoes, and process the received signals to detect and report the presence of clouds. The transmit/receive cycles of the ceilometer are synchronized by a timing sequencer located on the processor board. The transmission cycle is started by activating the pulse trigger generator circuit. This circuit outputs a trigger pulse signal that fires the laser located on the transmitter board. The pulse trigger generator is controlled by a signal from the CPU and output control latch that allows the processor to enable and disable the generation of laser pulse transmissions.

The echo signal from the receiver board is first amplified and then converted into digital format by an A/D converter. The conversion process is performed synchronous to transmission cycles and produces a digitized sample corresponding to every 50 feet above the ceilometer. Each sample is stored in a specific RAM location dedicated for current samples. After all 254 samples (12,650 feet total) have been taken, the samples are added to the sums of previous cycles. The resulting accumulated values for each 50-foot increment are then stored in a section of RAM reserved for summed samples. After the required number of transmit/receive cycles have been completed, the CPU reads the accumulated sample sums and processes the data to generate the cloud report data that are transmitted to the DCP.

The processor board also monitors the ceilometer power supply voltages and other important system signals. The checking of these signals is an integral part of the self-test capability of the ceilometer, which is capable of detecting and isolating the majority of faults that may occur within the system. The voltages and signals are monitored by an analog multiplexer and A/D converter circuit. The CPU selects the signal to be monitored using control lines to the multiplexer. The selected signal is then patched to the input of the A/D converter where it is digitized. The CPU reads the resulting digitized signal data and processes the data to determine if within tolerance limits or other suitable parameters. The actual signals monitored by the processor board are identified and described in the paragraphs for each of the other ceilometer components.

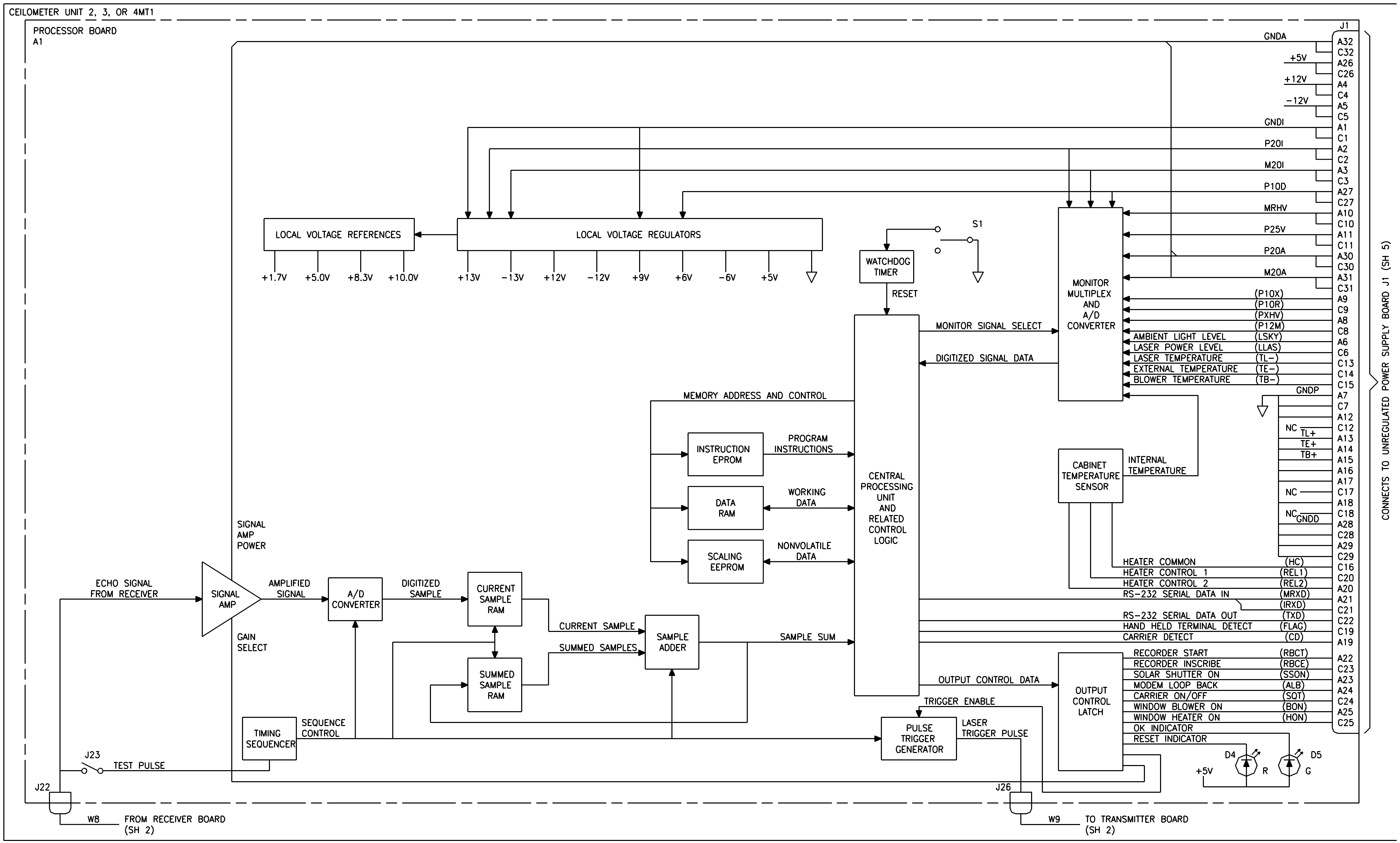

Figure 9.4.4. Ceilometer Detailed Block Diagram (Sheet 1 of 6)

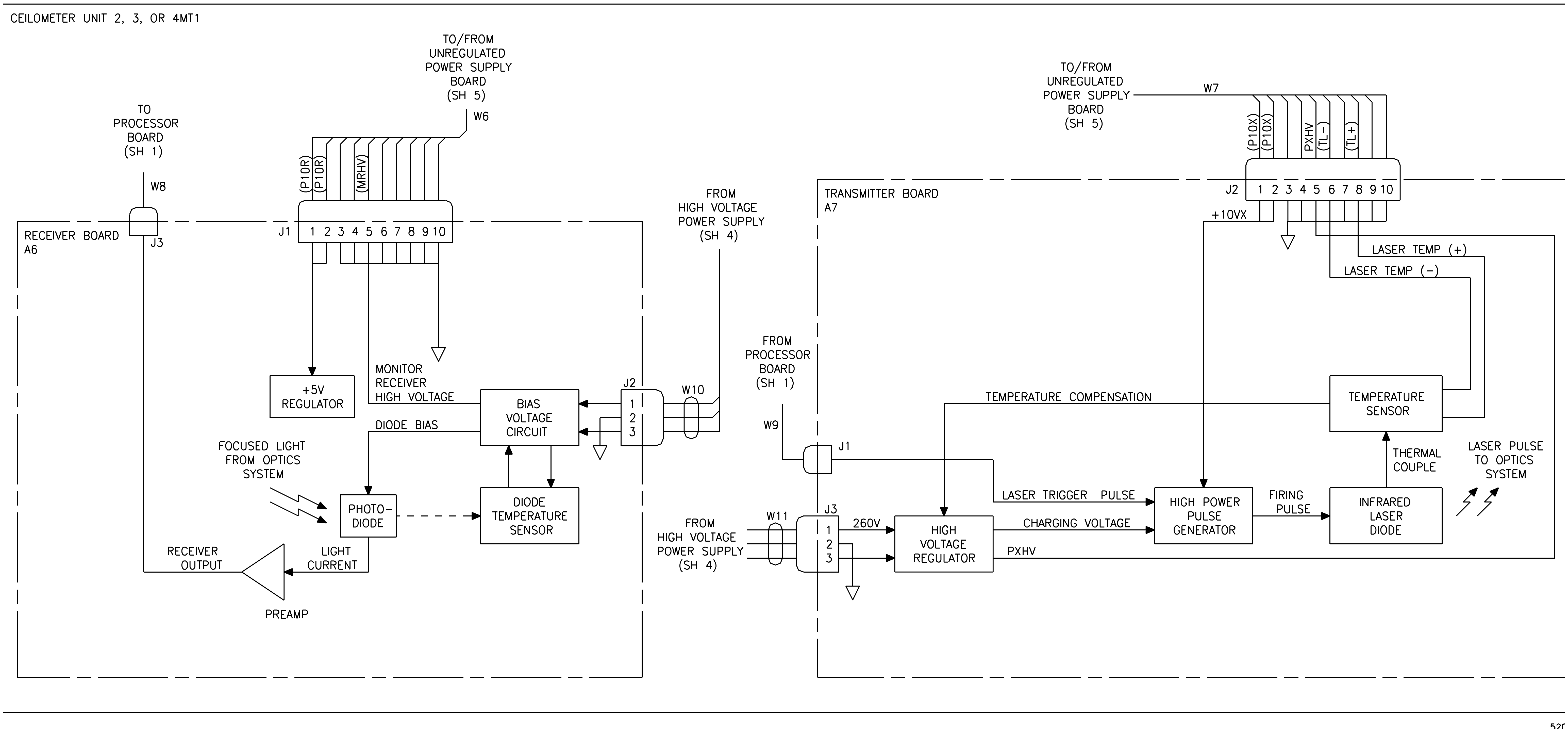

Figure 9.4.4. Ceilometer Detailed Block Diagram (Sheet 2)

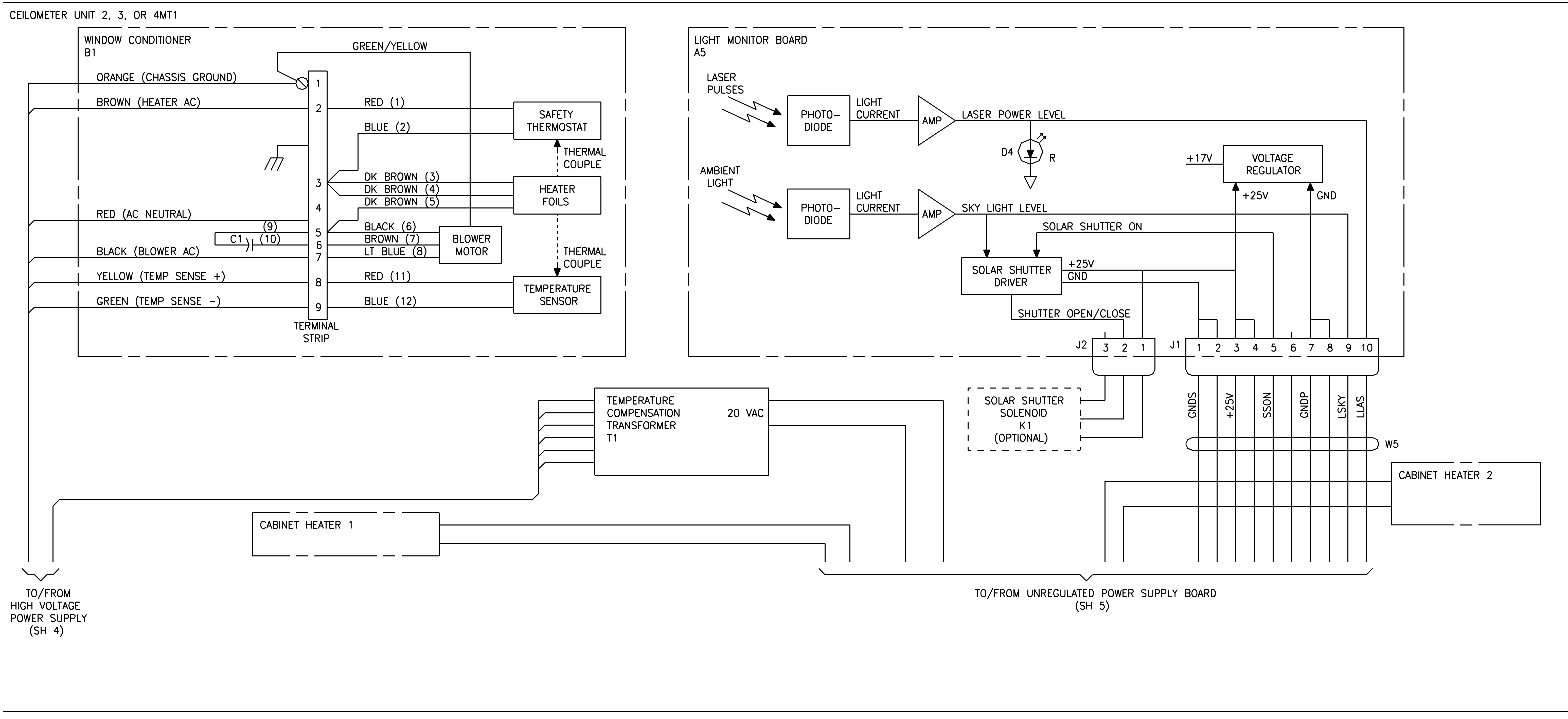

Figure 9.4.4. Ceilometer Detailed Block Diagram (Sheet 3)

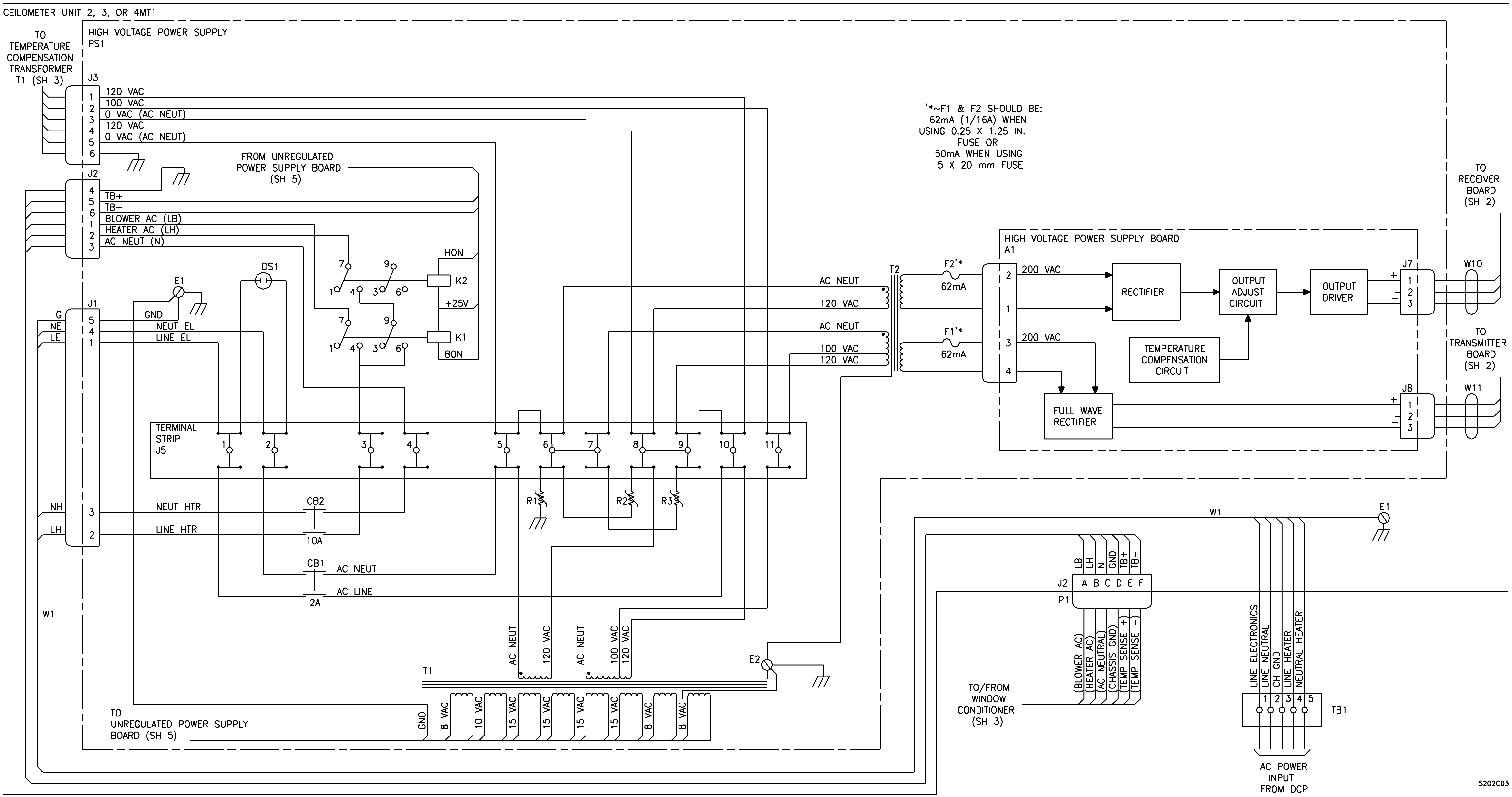

Figure 9.4.4. Ceilometer Detailed Block Diagram (Sheet 4)

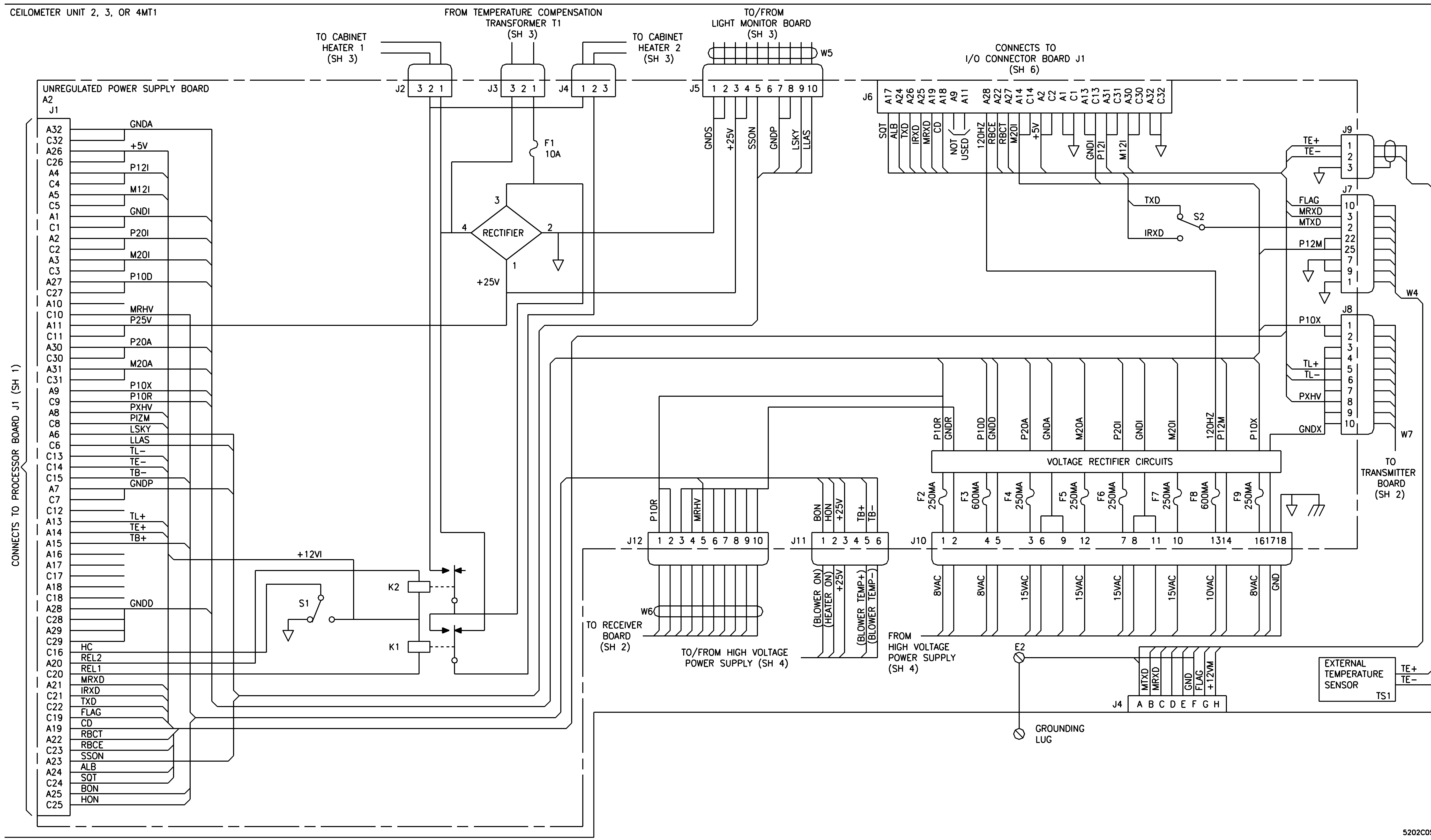

Figure 9.4.4. Ceilometer Detailed Block Diagram (Sheet 5)

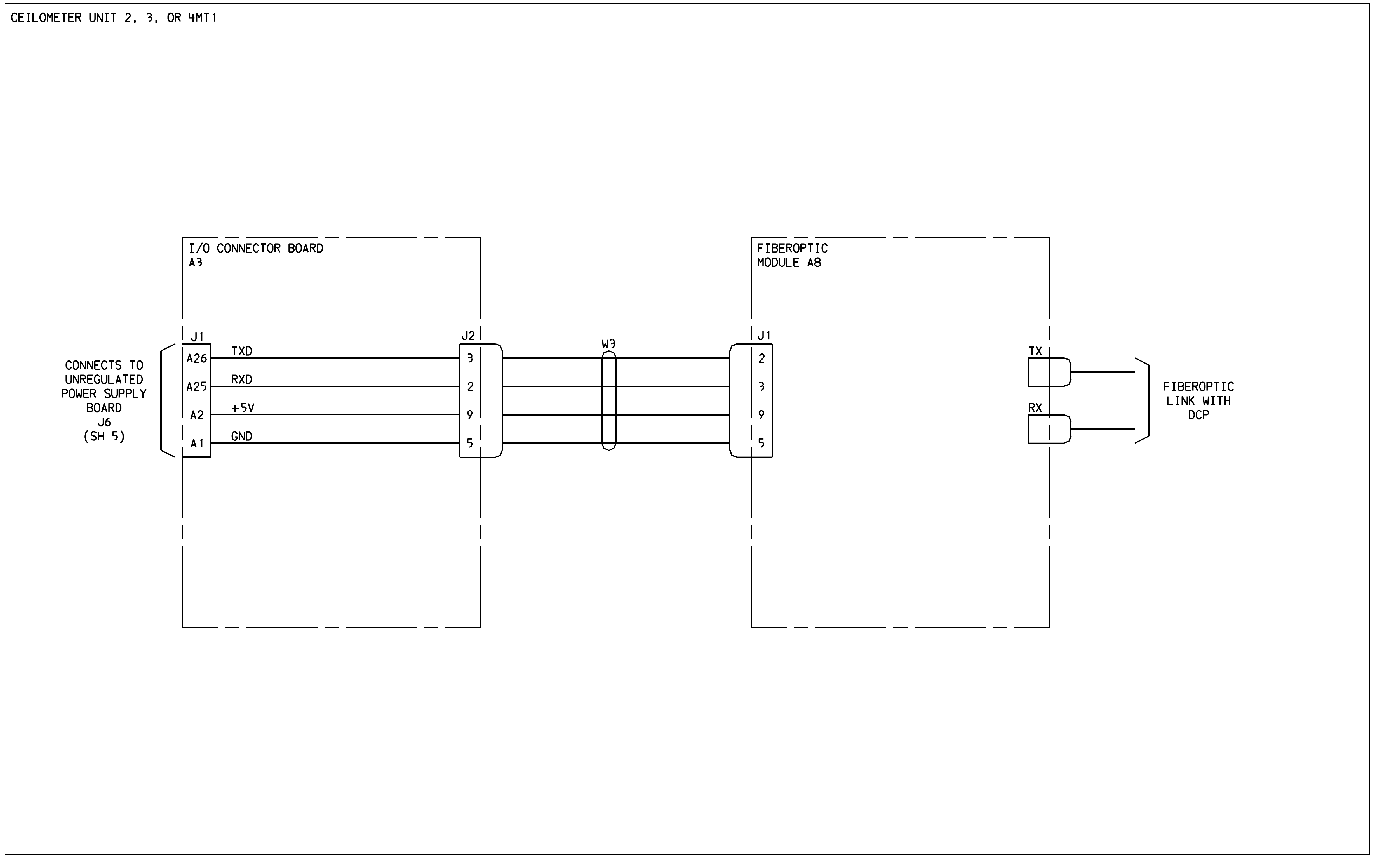

Figure 9.4.4. Ceilometer Detailed Block Diagram (Sheet 6)

The processor board is designed to be easily maintained. In addition to the automatic self-test capability of the system, test points are provided throughout the board (78 total). Many of these test points allow fault isolation down to the component level; however, for ASOS applications, only a subset of these test points is required for isolating faulty field replaceable units (FRU's). The actual test points are identified as a part of the corrective maintenance procedures provided in Section V.

9.4.3.3 **Transmitter Board**. Transmitter Board A7 generates the infrared laser light pulses used by the ceilometer to detect clouds. The laser pulses output by the transmitter board are focused by the ceilometer optics for transmission into the atmosphere. Each laser pulse is generated under processor control as a part of the overall ceilometer operating sequence. The operation of the transmitter board is also monitored for report back to the processor board.

The transmitter board receives high voltage power from the high voltage power supply and low voltage power from the unregulated power supply. The low voltage power (+10VX) is used to bias the high power pulse generator circuits. The high voltage (+260 vdc) power is applied to an on-board high-voltage regulator. This regulator circuit provides stable high-voltage power for transmitter board circuitry. Both the low- and high-voltages for the transmitter board are monitored by the processor board for diagnostic purposes. The low voltage power (+10VX) is monitored by the processor board directly from the unregulated power supply board. The high-voltage regulator circuit on the transmitter board is monitored using a scaled test signal (PXHV), which is routed to the processor board via the unregulated power supply board.

The laser light pulses are produced by the infrared laser diode on the transmitter board. When the ceilometer is to produce a laser pulse, a pulse trigger generator on the processor board outputs a laser trigger pulse to the transmitter board. This pulse causes the high power pulse generator on the transmitter board to output a high voltage firing pulse to the infrared laser diode. The firing pulse causes the diode to emit a pulse of infrared light. The light pulse is then output to the atmosphere via the ceilometer optics.

The operation of the infrared laser diode is affected by temperature. As the temperature of the diode increases, a greater voltage is required to fire the diode. For this reason, the transmitter board contains a temperature compensating circuit. A temperature sensor monitors the operating temperature of the laser diode. This sensor outputs a temperature compensation feedback signal that is applied to the high voltage regulator circuit, where it adjusts the voltage output by the regulator. This design provides continual compensation for the temperature of the laser diode to obtain consistent performance. The temperature of the laser diode is also monitored by the processor board using two laser temperature signals (TL+ and TL-) provided by the temperature sensor circuit. These signals are routed to the unregulated power supply board, where they are passed to the processor board. This allows the processor board to detect proper operation of the laser diode transmitter automatically.

9.4.3.4 **Receiver Board**. Receiver Board A6 detects reflections of the transmitted laser pulses. Light energy from the sky above the ceilometer is focused by the ceilometer optics onto a photodiode located on the receiver board. The receiver board converts this light energy to an electrical voltage signal for output to the processor board. The processor board uses this voltage signal to determine the presence and location of clouds. The operation of the receiver board is also monitored and reported to the processor board. A tropical receiver board (part No. 62828-90112-11) is installed on ceilometers that are equipped with a solar shutter and a standard receiver board (part No. 62828-90112-4) is installed on ceilometers without a solar shutter. The difference between the tropical and standard receiver boards is that the tropical receiver board is equipped with a type of filter that protects the transmitter optics from the effects of direct sunlight.

The operation of the receiver board requires both a high voltage power supply and a low voltage power supply. The low voltage power (+10 vdc) is applied from the unregulated power supply board to the local voltage regulator on the receiver board. This power source is used to derive the +5 vdc power required by the receiver board circuitry. A high voltage bias for the photodiode (ranging from -250 to -425 vdc) is provided by the high voltage power supply in the ceilometer. Both of these power sources are monitored by the CPU on the processor board. The low voltage power (+10VR) is monitored directly from the unregulated power supply board. The high voltage power is routed from the regulated high-voltage power supply, passed through the receiving board scaling resistors, unregulated power supply board (MRHV), and is applied to the processor board. This allows the CPU to detect power supply failures involving the receiver board.

The focused light energy on the receiver photodiode causes the photodiode to generate a low level electrical current. The more light energy applied to the photodiode, the more electrical current output. This low level dc current is applied to a preamplifier circuit that produces a corresponding voltage level output to the processor board. The processor board samples the receiver board output voltage to detect the presence of cloud reflections resulting from the laser pulse transmissions.

The response of the photodiode on the ceilometer receiver board is highly sensitive to both bias voltage and temperature. A diode temperature sensor monitors the photodiode level and adjusts the photodiode bias voltage circuit to compensate for the photodiode operating temperature. As a result, the receiver operates with constant sensitivity and improved performance.

9.4.3.5 **Light Monitor Board**. Light Monitor Board A5 is located between the laser transmitter lens and the instrument cover window. The circuit functions to monitor both the average power level of the laser transmission pulses as well as the ambient light level of the sky. In addition, the light monitor board is used to drive the optional solar shutter. All electrical power required by the circuitry is derived from the unregulated power supply board. Local voltage regulators on the light monitor board control the power input to provide stable dc supply power.

The average laser power level is detected by a photodiode that is pointed toward the laser transmitter. The photodiode converts a portion of the laser-radiated light pulses into low-level electrical current pulses, the peaks of which are passed through Schottky diode D2 and filtered by capacitor C2. D2 blocks the low-level photovoltage produced by ambient light entering the transmitter optics, but laser light pulses are passed by D2 and converted to an analog voltage which varies proportionally with pulse intensity, duration, and repetition rate.

This dc voltage is applied to the noninverting input of differential comparator U1A. Threshold voltage for U1A is applied by Monitor Gain Adjust potentiometer R6, which also provides offset compensation. The dc output voltage of differential comparator U1A, which can be measured at TP1, is termed the Laser Power Signal (LLAS). LLAS is routed through the unregulated power supply board for application to the processor board. The CPU on the processor board monitors the laser power level via an A/D converter. The LLAS voltage also drives a red LED (D4) located on the light monitor board.

The ambient light level of the sky is processed in a similar manner. Photodiode D3 is pointed skyward to convert ambient skylight into electrical current, which develops a positive dc voltage level across resistor R4 and capacitor C3. Voltage follower U1B provides a voltage gain of 1 for the high-impedance photodiode but a low-impedance output to drive the analog Sky Light (LSKY\) signal line, which is routed to the processor board, via the unregulated power supply board, for monitoring by the CPU.

The sky light voltage (LSKY) is also applied to the solar shutter driver circuit on the light monitor board. This positive voltage level, compared in differential comparator U1D to a threshold level derived from potentiometer R13, determines whether the solar shutter (if installed) should be closed to protect the laser transmitter. Normally, R13 is adjusted for 2.0V at TP4, which corresponds to an incident skylight power of 32W/m^2. If LSKY exceeds reference voltage level (indicating considerable direct sunlight into the ceilometer) the solar shutter solenoid will be deactivated to close the shutter and protect transmitter optics. When the solar shutter solenoid is activated, it opens; conversely, when deactivated, it closes. This design protects transmitter optics in the event of a malfunction or power loss to the ceilometer.

The processor board also controls activation of the solar shutter in response to the Sky Light (LSKY) signal from the light monitor board to protect the transmitter against focused skylight from zenith. It uses fail-safe logic so that the microprocessor can close the shutter when it should be closed but cannot open the shutter when it should be closed as determined by the sky light monitor circuit on the light monitor board. The SOLAR SHUTTER ON signal (SSON) is generated by the output control latch on the processor board. SSON is routed through the unregulated power supply board to the solar shutter driver circuit on the light monitor board, where it is applied to the base of PNP transistor Q1. When SSON is high (inactive state), Q1 is on to drive PNP Darlington pair Q2 to saturation. Q2 collector current then keeps solar shutter solenoid K1 energized to hold the shutter open - provided that the skylight monitor circuit is not detecting excessive ambient skylight. Because SSON signal is active (low), transistor Q1 will be off and the shutter will normally be closed unless the processor opens it by activating SSON; if analog signal LSKY is of sufficient amplitude (positive), then the inverting input of differential comparator U1D will cause its output to swing negative, thereby cutting Darlington pair Q2 off to keep the shutter solenoid deenergized (closed), regardless of the state of SSON from the processor board. This feature prevents the transmitter optics from being damaged by focused light during transmission cycles.

9.4.3.6 **Window Conditioner**. Window Conditioner B1 performs two functions for the ceilometer: it keeps the windows on the ceilometer clear of precipitation and dust and assists in regulating the cabinet temperature of the ceilometer. The window conditioner is controlled by the processor board via two power relays in the high voltage power supply.

AC power for the window conditioner is controlled by high voltage power supply circuit breaker CB2 and relays K1 and K2. The circuit breaker provides current limiting protection for the window conditioner while also providing a convenient means to manually remove power from the window conditioner. Relays K1 and K2 control the heater and blower components of the window conditioner, respectively. These relays are configured such that power cannot be applied to the window conditioner heater unless the blower is on. The heater assembly in the window conditioner provides 600 watts nominal heating power. The blower housing is designed to move air over the heater and sweep it across the windows. The combination of warmed, moving air evaporates moisture from the windows while helping to prevent dust and dirt buildup on the window surface.

The operation of the window conditioner is controlled by the processor board. As a part of this processing, the processor board monitors the external air temperature using the external temperature sensor located on the underside of the ceilometer. The sensed temperature signals (TE+ and TE-) report the air temperature to the processor board via the unregulated power supply board. In response to this input and other processing criteria, the processor outputs the WINDOW BLOWER ON signal (BON) and WINDOW HEATER ON signal (HON). These signals are routed through the unregulated power supply board and are applied to relays K1 and K2 in the high voltage power supply. HON and BON energize their respective relays and thereby connect ac power to the window conditioner heater and blower.

The operation of the window conditioner is also monitored by the processor board. A temperature sensor in the window conditioner provides a voltage signal that is routed from the window conditioner and through the high voltage power supply and unregulated power supply board and is applied to the processor board (TB+ and TB-). The processor board monitors this signal to determine the desired operating mode for the window conditioner, as well as to detect failures of the window conditioner. As an additional precaution, the window conditioner also contains a safety thermostat. The safety thermostat removes ac power from the heater in the event of a malfunction that causes an overtemperature condition (256 ±6°F or 124 ±3°C) in the window conditioner. The processor board receives no direct report of safety thermostat operation.

The ceilometer operating software continually monitors the external temperature and blower temperature to switch the window conditioner heater and blower on and off as required. These two data inputs are also used to determine malfunctions involving the window conditioner. In addition, the software uses time references to switch the blower on and off by itself during periods when window heating is not necessary. This keeps the windows free from dust and debris. The heat and airflow are also used to regulate cabinet temperature conditions. In cold weather (below 14°F or -10°C), the heater and blower are constantly on to help heat the ceilometer cabinet. In hot weather (above 86°F or 30°C), the heater remains off and the blower remains on. This helps to combat heating of the ceilometer by solar radiation.

9.4.3.7 **High Voltage Power Supply**. High voltage power supply PS1 is the ac line power entry point for the ceilometer. The high voltage power supply performs three basic functions. First, the ac input power is transformed into low voltage ac power needed to supply the ceilometer electronics. Second, the ac input power is rectified, filtered, and partially regulated to generate the high power dc voltages required by the transmitter and receiver boards. Finally, the ac line power is switched and controlled for application to the ceilometer window conditioner.

The ac line power is input to the ceilometer at connector J1. The power is then routed to the high voltage power supply for application to terminal strip J5, LINE VOLTAGE indicator DS1, and circuit breakers CB1 and CB2. The ac power indicator is wired in front of the circuit breakers to show the presence of ac power regardless of the state of the circuit breakers. The circuit breakers double as on/off switches and circuit protectors. The dual pole configuration of the circuit breakers allows the use of a floating or nonspecified line voltage. Circuit breaker CB2 controls the application of ac power for the window conditioner power via relays K1 and K2. Operation of these relays is described in the operating theory for the window conditioner. Circuit breaker CB1 controls the application of ac power for the ceilometer electronics. The ac power is distributed by terminal strip J5, where surge protectors R1 through R3 are located. This power is distributed to transformers T1 and T2 and to the temperature control transformer via terminal strip J3. Transformer T1 supplies the low voltage ac power to the unregulated power supply board. Transformer T2 provides the ac power required by the high voltage power supply board. These ac power lines are current-protected by fuses. The values of these fuses are critical to the operation of the ceilometer and are noted as such on the detailed block diagram.

The high voltage power supply board in the high voltage power supply generates the high voltage dc power required by the ceilometer transmitter and receiver boards. The transmitter power is derived by full wave rectifying the ac input voltage. This produces an unregulated dc power level in the range of +260V. The receiver power is also generated by rectifying the ac input power. The resulting dc power is then partially regulated and compensated for temperature effects to provide an output dc power source of +250 to +425 vdc.

9.4.3.8 **Unregulated Power Supply Board**. Unregulated Power Supply Board A2 is a central support board for the ceilometer. The board rectifies and filters several low voltage ac power sources for use by the various electronics. The board also provides signal routing between the ceilometer component boards and contains the relays that control ceilometer cabinet heating.

The unregulated power supply board receives low voltage ac power from the ceilometer high voltage power supply at connector J10 and from the temperature compensation transformer at connector J3. All of the ac power inputs are fuse protected, rectified, and filtered. All of the resulting dc voltages are unregulated; line inputs and load fluctuations cause variations in the actual dc voltages obtained. The dc power is applied to the other ceilometer electronics where local voltage regulators stabilize the power. The dc voltages produced on the unregulated power supply board are also applied to the processor board where they are monitored as a part of the automatic testing of the ceilometer.

Ceilometer cabinet temperature is controlled by two relays (K1 and K2) located on the unregulated power supply board. The relays are controlled by a cabinet temperature sensor circuit located on the processor board. This circuit monitors the ceilometer internal cabinet temperature and reports the temperature to the processor via the monitor multiplex A/D conversion circuit. The circuit also generates the heater control signals required to energize relays K1 and K2 on the unregulated power supply board. These control signals are generated independently from the processor and are not controllable by software. The relays function to switch 20 vac power input from temperature compensation transformer T1 to the two cabinet heater elements. At temperatures above approximately 68°F (20°C), power to both heaters is removed. At cabinet temperatures between 32°F and 68°F (0°C and 20°C), relay K1 is activated. This connects the two cabinet heaters in series and provides two 10-watt sources of heat. At cabinet temperatures below 32°F (0°C), relay K1 is off and relay K2 is activated. This connects the two cabinet heaters in parallel and provides two 40-watt sources of heat. An override switch (S1) is provided on the unregulated power supply board. By setting the switch to the off position, relays K1 and K2 cannot be activated, and power is removed from the cabinet heaters. This switch is intended for temporary maintenance activities, and is therefore kept in the on position for normal operation.

9.4.3.9 **Fiberoptic Module**. The fiberoptic module added to the ceilometer for the ASOS provides the data communications link with the DCP. The fiberoptic module is interfaced to connector J4 on the ceilometer, which is normally reserved for the ceilometer maintenance terminal. For the ASOS, however, the maintenance terminal is not required for normal operation, which allows connector J4 to be available for the fiberoptic module. The fiberoptic module converts electrical data signals (RS-232 serial data) to light pulse signals that are transferred to the DCP. The RS-232 interface data transmit signal (TXD) originates on the processor board and carries the data messages from the ceilometer to the DCP. The signal is routed through the unregulated power supply board to interface connector J4. Switch S2 on the unregulated power supply board is normally set to connect the TXD signal to provide the MTXD signal to the fiberoptic module. In the other position, switch S2 passes the received data signal (IRXD) from the I/O connector board to the fiberoptic module. The TXD signal is also connected to the I/O connector board. The RS-232 interface data received signal (MRXD) is input from the fiberoptic module and carries the data messages from the DCP to the ceilometer. The MRXD signal is routed through the unregulated power supply board and is applied to the processor board. The MRXD signal is also applied to the I/O connector board.

9.4.3.10 **I/O Connector Board**. I/O Connector Board A3 is the communications link circuit of the ceilometer. In the ASOS configuration, the I/O connector board provides the RS-232 interface required for the fiberoptic module. All data transmissions from the ceilometer originate from the processor board. The RS-232 serial transmitted data signal (TXD) is routed from the processor board to the I/O connector board via the unregulated power supply board. The data signal is applied to a standard DB-9 connector for output to the fiberoptic module. The ceilometer receives data via the same circuitry used for transmitting data. The data signal is input from the fiberoptic module and applied to the DB-9 connector on the I/O connector board. The received data signal is output as IRXD and routed through the unregulated power supply board to the processor board.