VLBA Weather Station

by

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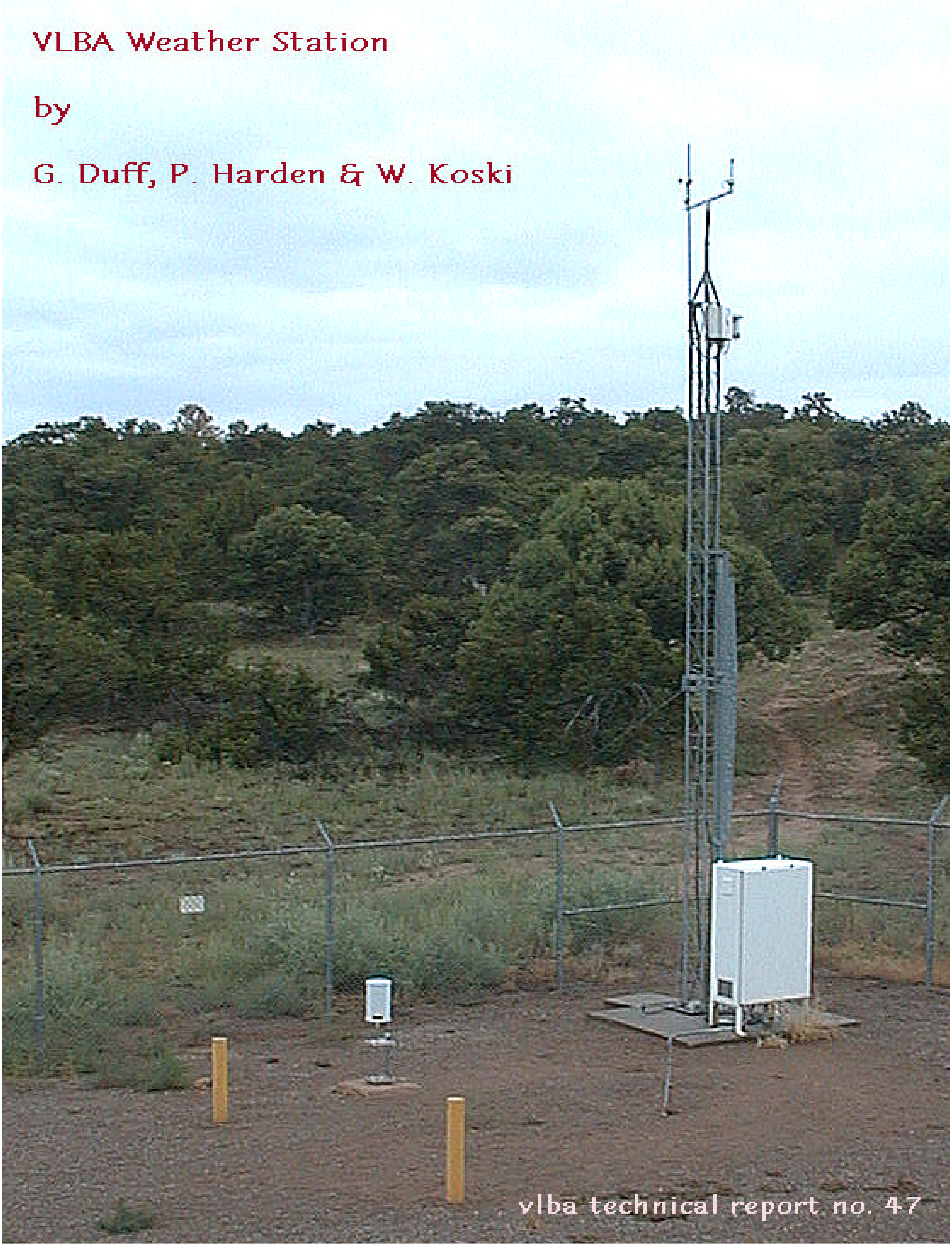

vlba technical report no. 47

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Introduction

This manual describes the VLBA Weather Station, an instrument to measure and record atmospheric conditions at each VLBA antenna site. The weather station is multi-component, and includes devices for measuring the ambient temperature, dew point, wind speed, wind direction, atmospheric pressure, and rainfall. The sensors are electrical devices that respond to atmospheric changes, thus generating scaled analog signals that are converted into digital form for ease of data communication and event recording via a time serial Monitor and Control Bus.

Manual Overview

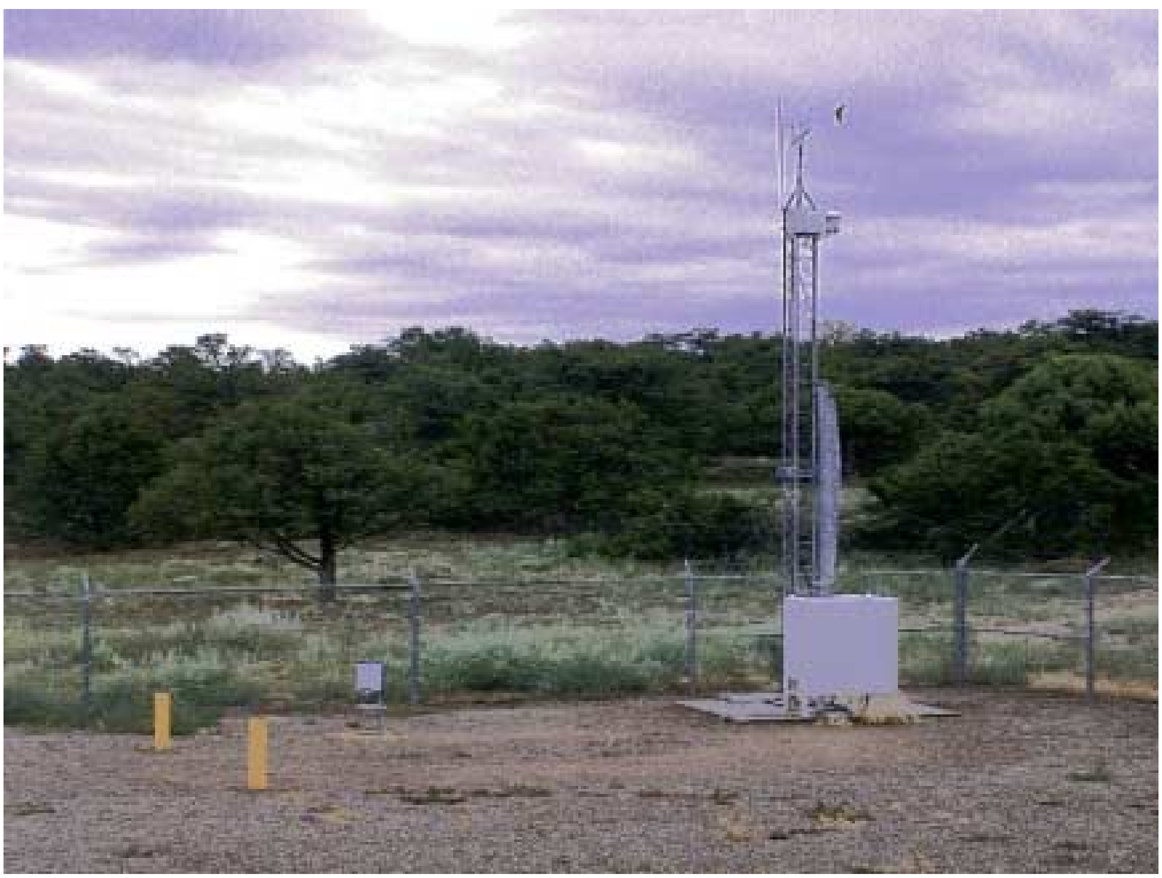
This manual provides functional descriptions of the weather station, each sensor, and panel mount assemblies inside the electronics enclosure. Descriptions of any additional hardware assemblies are included. The sensors and the panel mount assemblies are explained in detail in each sub-section in the theory of operation. Schematics, wiring diagrams, cable interconnections, enclosures, tower, and panel mounting information for the weather station are also in this manual. The appendices are the product manuals for the TSL Model 1063 Hygrothermometer, the Qualimetrics sensors and instrumentation, the A.I.R. barometer, the power supply, and the box heater. Also included is an appendix for the schematics and drawings referred to in the text portion of this manual.

VLBA Weather Station Overview

Each weather station has a 10m tower for mounting the TSL Hygrothermometer, wind speed and wind direction sensors. A hank-crank winch allows for lowering and raising the tower when sensor replacement or maintenance is necessary. A lightning rod, ground strap and copper rod are used in concert for a low resistance path to ground in the event of lightning strikes.

The bulk of the electronics are housed in a NEMA 4 standard type enclosure placed next to the tower for convenient cable interconnection. The various signal processing and conditioning circuit boards, terminal strips, power distribution, surge protection, heater, and barometer are panel mounted within the enclosure. Situated near the enclosure is the rain gauge. The tower, electronics enclosure, and rain gauge are mounted on a level concrete slab adjacent to each antenna.

Plate 1 illustrates the VLBA Weather Station tower & sensors, electronics enclosure and rain gauge.



Monitor and Control functions are routed through a VLBA Standard Interface Board and interfaces to the VLBA Telescope Monitor and Control System. It is panel mounted inside the enclosure. The Standard Interface Board functions as a serial-parallel converter to interface the Monitor and Control Bus to the devices that are to be controlled or monitored. Through this system weather conditions can be monitored remotely in real-time as long as there is power at the VLBA antenna site and the main commercial communication link is operative.

Fiber optic cable is used for the communication link from the electronics enclosure to the station control building. This was the preferred method chosen to isolate the weather station from the control building in case of lightning strikes to the 10m tower.

Figure 1 is the VLBA Weather Station Control Drawing, C55006Y001. It is a generalized drawing that exemplifies the general layout, construction, and components of the weather station at a VLBA antenna site.

VLBA Weather Station Functional Description

The purpose of the VLBA Weather Station is to measure atmospheric conditions at each VLBA antenna site, and is a system level component of the VLBA Telescope Monitor and Control System. The weather station does several important tasks necessary for observational data, operational status and safety at each antenna.

Measurements of the ambient temperature, dew point, and barometric pressure are used to calculate the amount of water vapor in the lower atmosphere. Corrections can then be made for pointing the antenna with respect to the position of the observed radio source. Additionally, any rapid changes, for example a large drop in the barometric pressure can indicate an approaching storm condition. The barometer can also be used as an indicator for any variance in altitude at site locations.

For safety there are three wind speed sensors at each VLBA antenna site. One is on the 10m tower and is the weather-recording instrument. Although not part of the weather station, the other two are mounted on opposite sides of the antenna dish. This redundancy is in case the position of the antenna blocks the weather tower from the wind, and provides a reliable method for determining when to stow and avoid climbing the antenna. The M106 Wind Speed Interface Module combines the wind status from all three sensors into a single condition for stowing the antenna. Harm to an antenna or personnel can occur in high wind conditions, and it is important to stay clear and stow the antenna before winds exceed the boundaries of safety.

Knowing the direction of the prevailing wind is important, especially during hurricane season in the Caribbean. By anticipating the direction a weather phenomenon or a fire is headed, preventive steps can be taken to protect equipment and personnel. Furthermore, wind loads are capable of increasing motor currents, and changing the position of the antenna in accordance to wind direction can prevent excessive current flow in the drive motors.

Measuring the amount of rainfall or snow accumulated at an antenna is useful to the observational log entry for interpreting data, and to indicate to VLBA Operations if there are conditions preventing site accessibility. In addition, snow loading can produce undue stress on the mechanical structures in the antenna dish, but the antenna dish may be pointed toward the sun to hasten the melting process of snow or ice. Also, prolonged

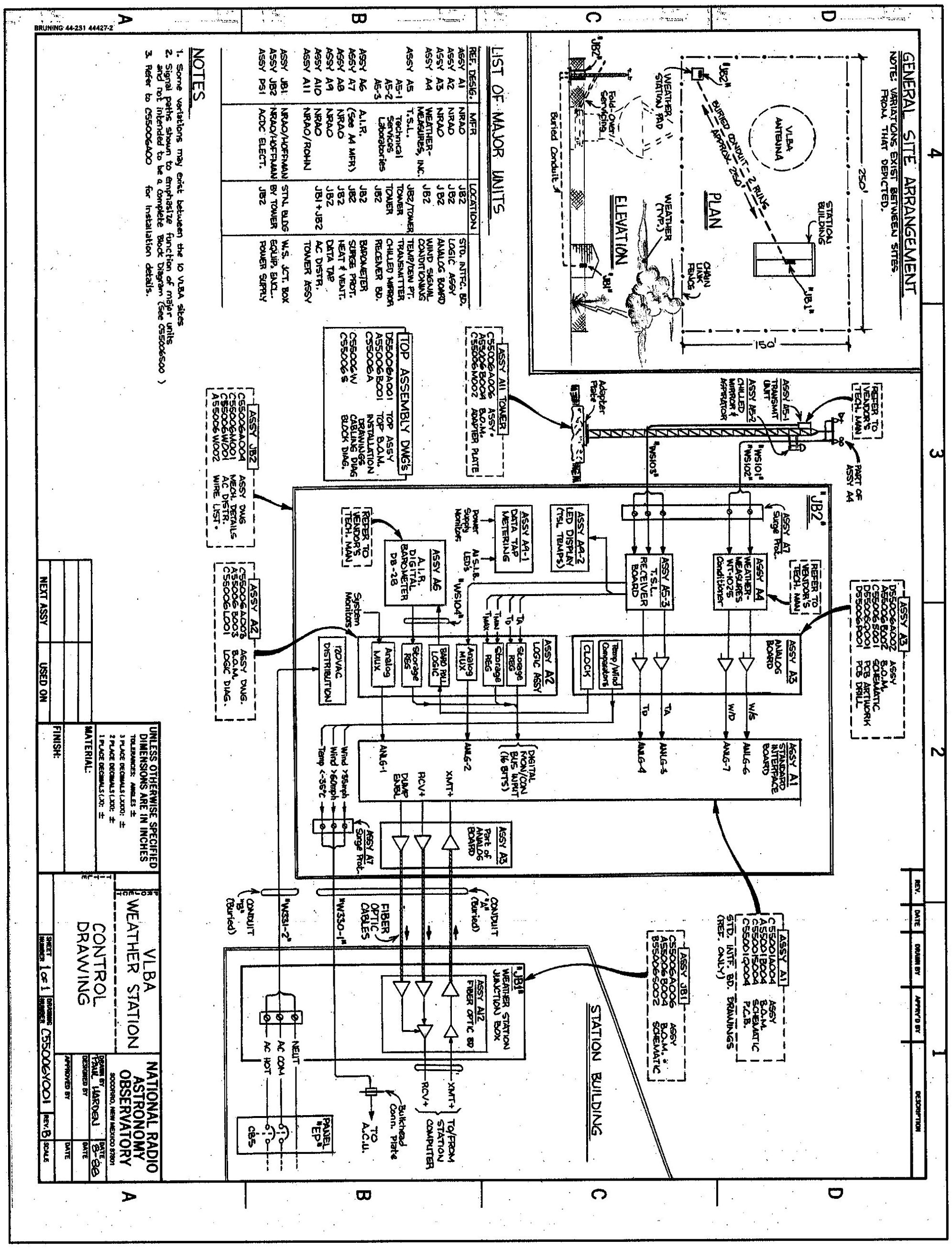


Figure 1 VLBA Weather Station Control Drawing, C55006Y001

periods of heavy rain or snow usually makes apparent any leaks, and moisture can find its way into almost anything dubbed critical to antenna operation.

Sensor Descriptions

TSL Model 1063 Hygrothermometer and Aspirator Assemblies

The TSL Model 1063 Hygrothermometer and Aspirator assemblies are the components used to measure the ambient and dew point temperatures, and shall be affectionately referred to as the TSL for convenience from this point forthwith.

In reality, the TSL is comprised of transducers, monitor and control circuitry, and power supply electronics. The ambient temperature is measured directly. The dew point temperature sensor utilizes a closed-loop servo-system that controls a chilled mirror to obtain the dew point measurement. Data is exchanged via the TSL transmit and receive boards through a serial communication cable running from the enclosure mounted on the tower to the electronics enclosure.

The ambient temperature and dew point sensors are located in the aspirator assembly. The aspirator assembly forces a uniform flow of air past the sensors and protects the dew point sensor assembly from the elements. It helps to eliminate any pressure gradients, moisture and contaminates from accumulating inside of the aspirator housing. Those conditions would interfere with dew point sensor accuracy.

A cable interconnection between the aspirator assembly and the TSL enclosure is the link between the sensors, the monitor and control circuitry, and the power supply.

Figure 2 is the VLBA Weather Station Temp/Dew Point Functional Loop Diagram, A55006W008. It is a generalized drawing that shows the various interconnections of the TSL, and Figure 3 is the Dew Point and Ambient Temperature Block Diagram.

Barometer

The barometer for the weather station is the Atmospheric Instrumentation Research (A.I.R.) Model AIR-DB-2AX. This instrument is a microprocessor controlled digital pressure transducer, and measures the atmospheric pressure in millibars.

The barometer is inside the electronics enclosure, and is connected to the digital electronics via a serial communication cable. The electronics inside the barometer are in a sealed weather resistant black anodized aluminum cover. Outside air is filtered to the barometer via a tube.

Figure 4 is the VLBA Weather Station Barometer Functional Loop Diagram, A55006W007. It is a generalized drawing that shows the various interconnections of the barometer, and Figure 5 is the Barometer Block Diagram.

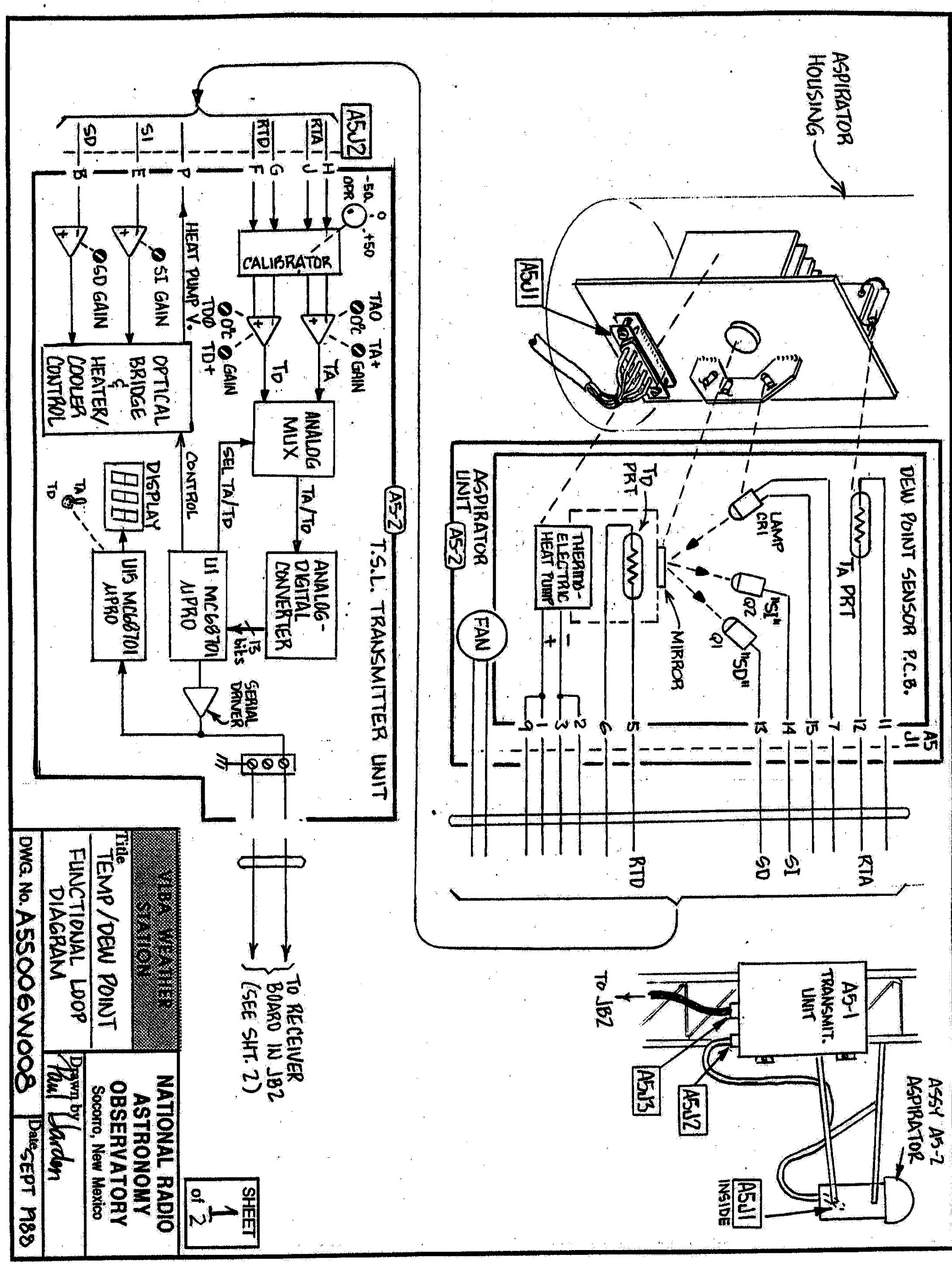


Figure 2 VLBA Weather Station Temp/Dew Point Functional Loop, A5506W008

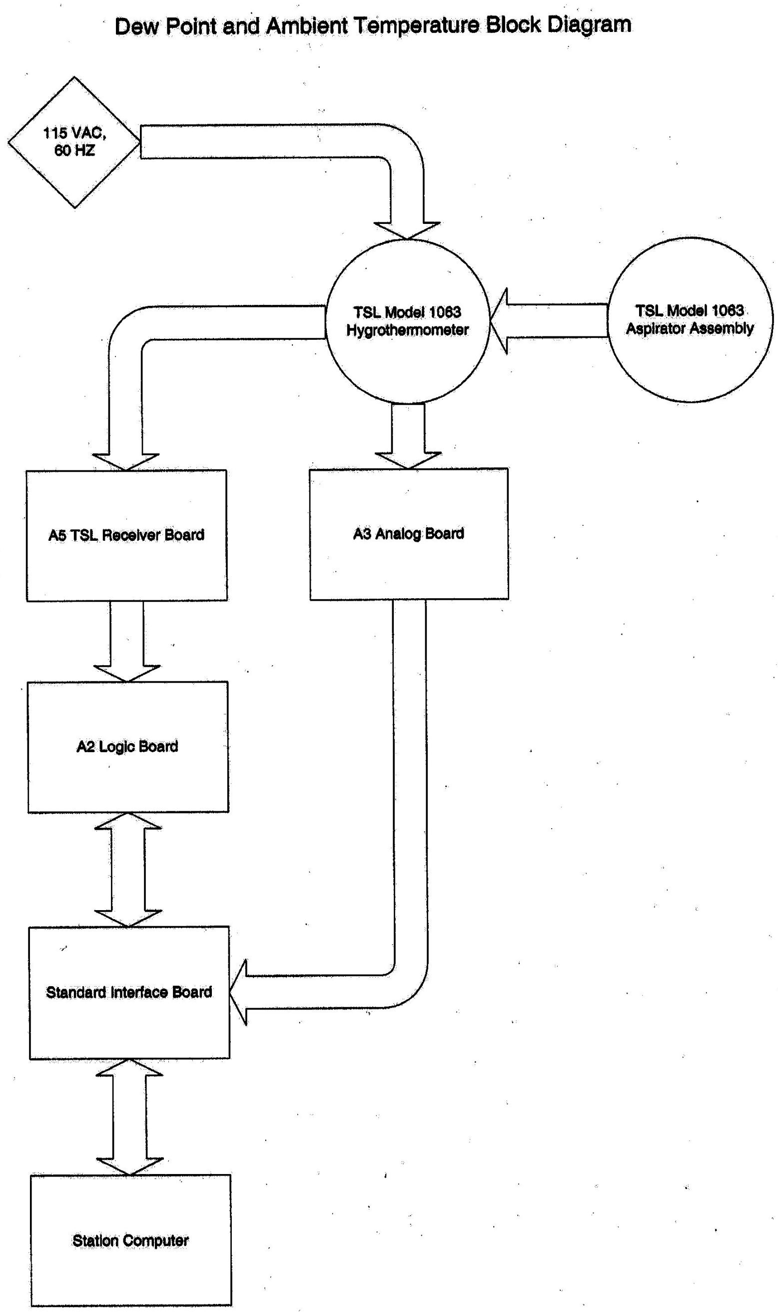


Figure 3 Dew Point and Ambient Temperature Block Diagram

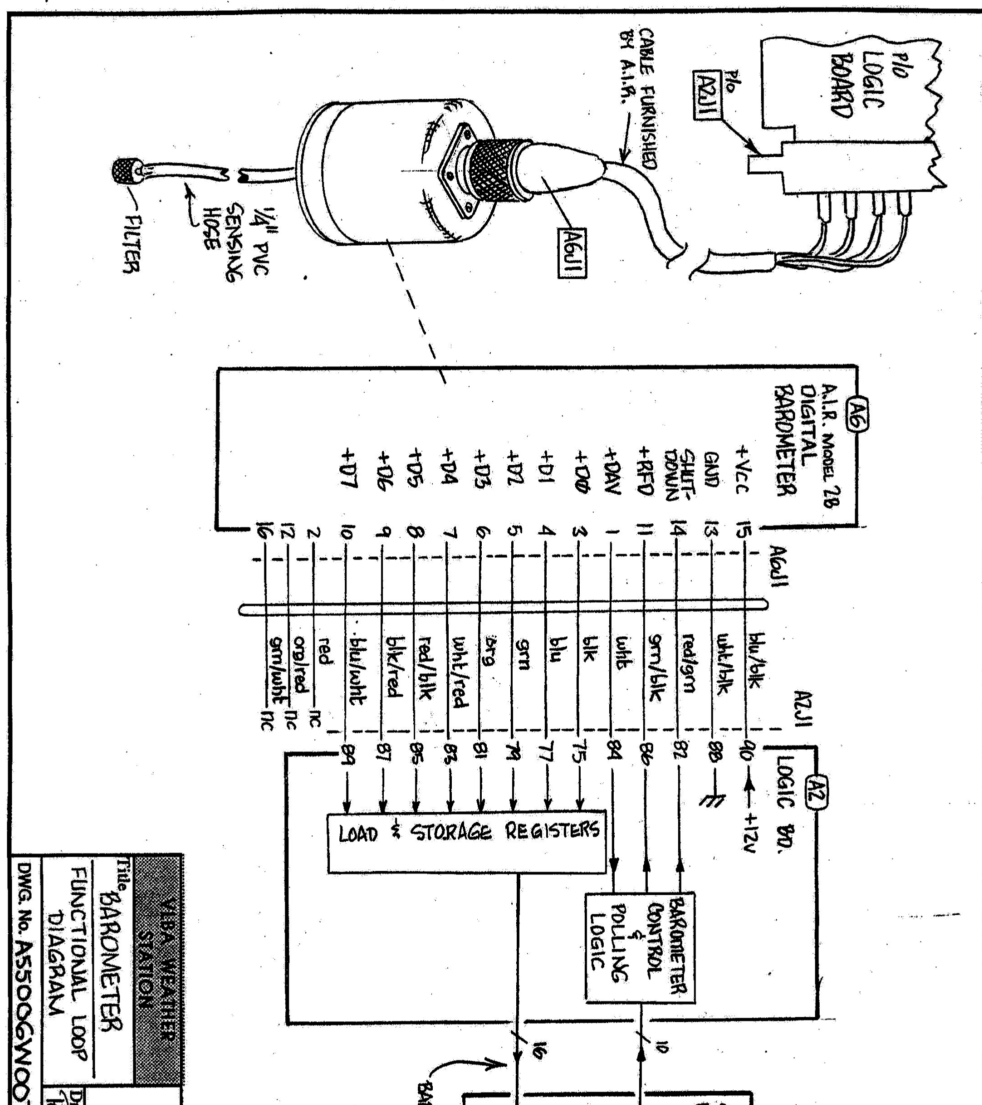


Figure 4 VLBA Weather Station Barometer Functional Loop Diagram, A55006W007

Barometer Block Diagram

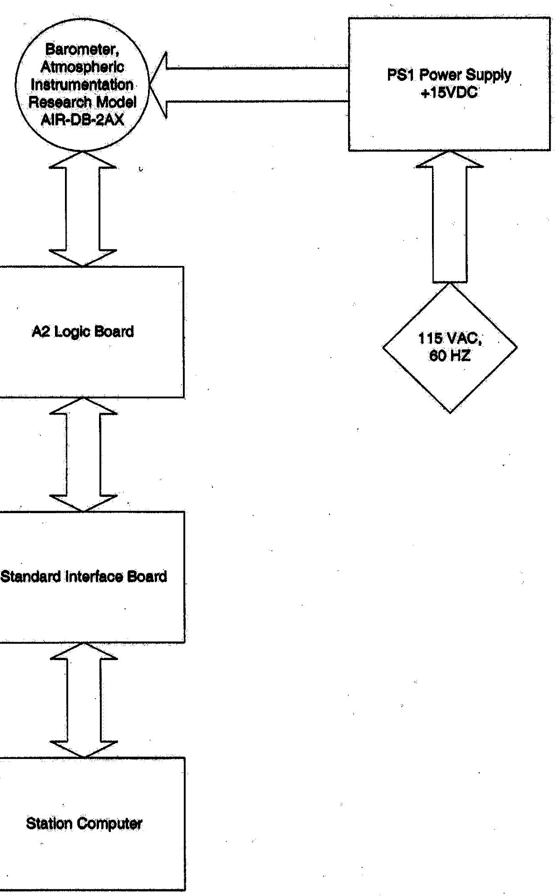


Figure 5 Barometer Block Diagram

Plate 2 illustrates the barometer.

Wind Speed Sensor

Each wind speed sensor is a Qualimetrics Model 2030. The sensor is a 3-cup anemometer, and is designed to measure low wind speeds.

The construction of the unit is stainless steel and anodized aluminum to resist corrosive environmental conditions. The interconnection is made with a quick release waterproof connector and a two twisted-pair shielded cable from the sensor to the electronics enclosure.

Wind Direction Sensor

The wind direction sensor is a Qualimetrics Model 2020. This is designed for high reliability and a low threshold wind direction response.

Construction is similar to the wind speed sensor, with the exception of the vane itself. It has a reinforced, lightweight foam tail with a butyrate skin and a stainless steel counterweight. Interconnection is through a quick release waterproof connector and a three-wire shielded cable from the sensor to the electronics enclosure.

Figure 6 & 7 are the VLBA Weather Station Wind Speed & Wind Direction Functional Loop Diagrams, A55006W005 & A55006W006 respectively. They are generalized drawings that show the various interconnections to both the sensors, and Figure 8 is the Wind Speed and Wind Direction Block Diagram.

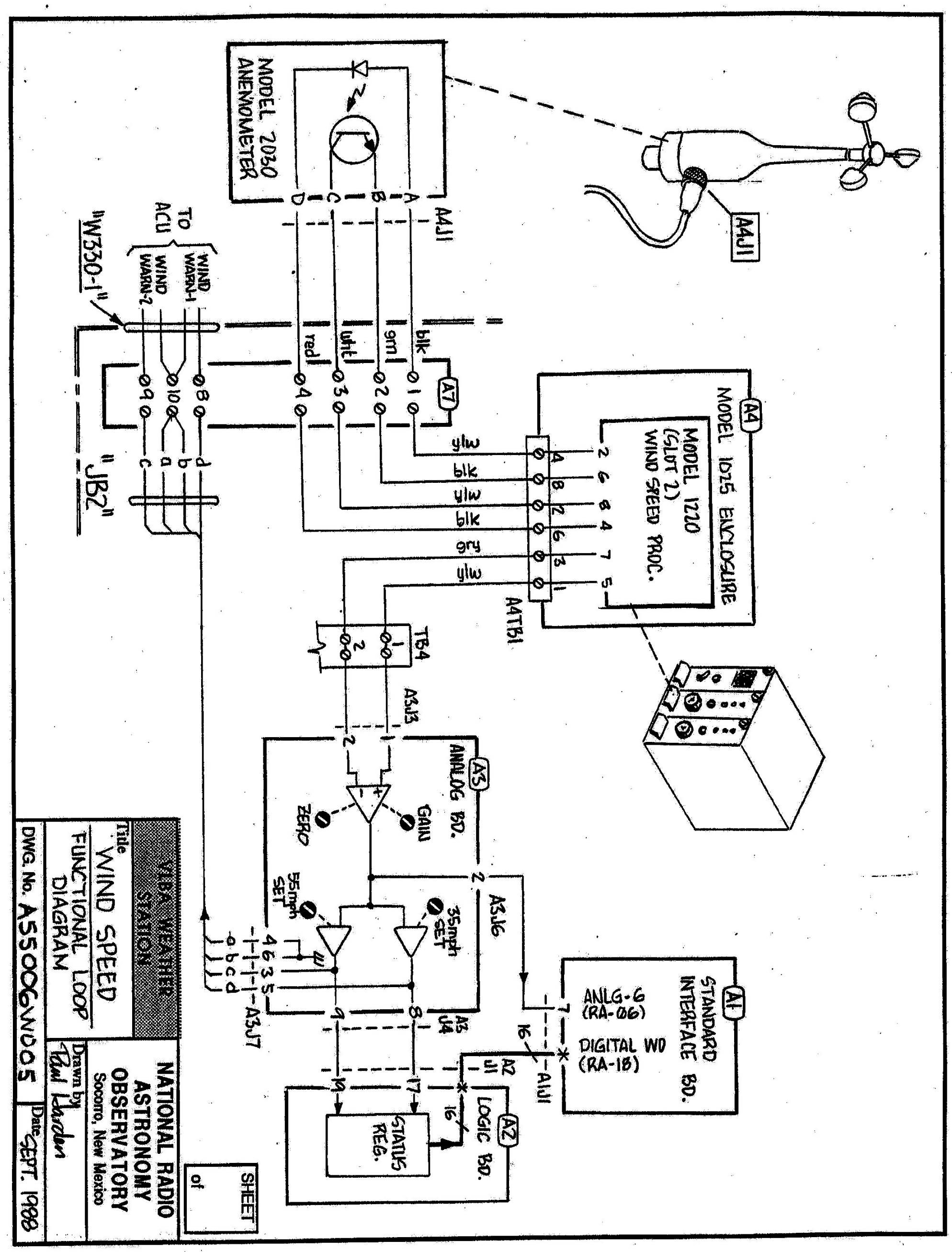


Figure 6 VLBA Weather Station Wind Speed Functional Loop Diagram, A55006W005

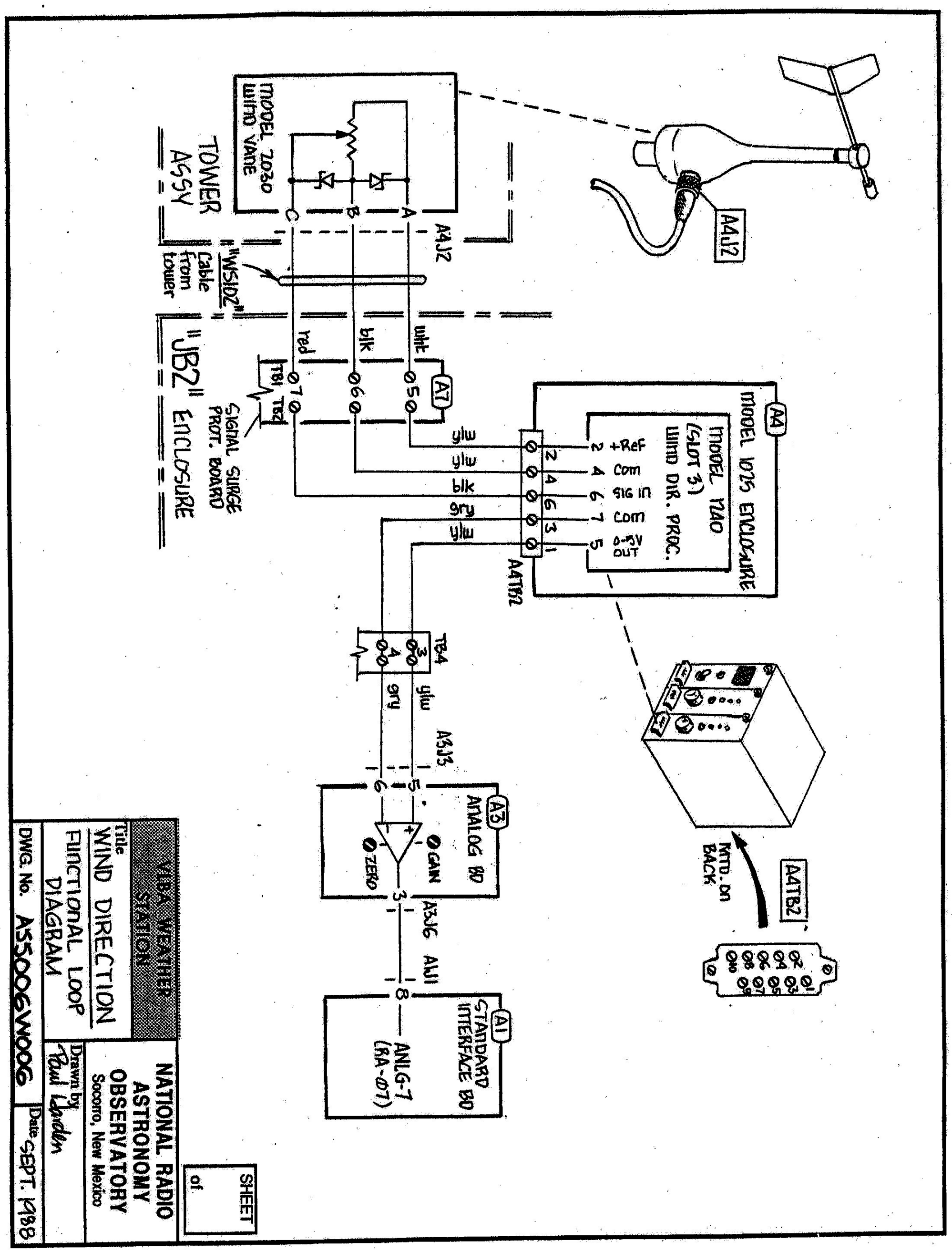


Figure 7 VLBA Weather Station Wind Direction Functional Loop, A55006W006

Plate 3 illustrates the TSL, the wind speed sensor and the wind direction sensor.

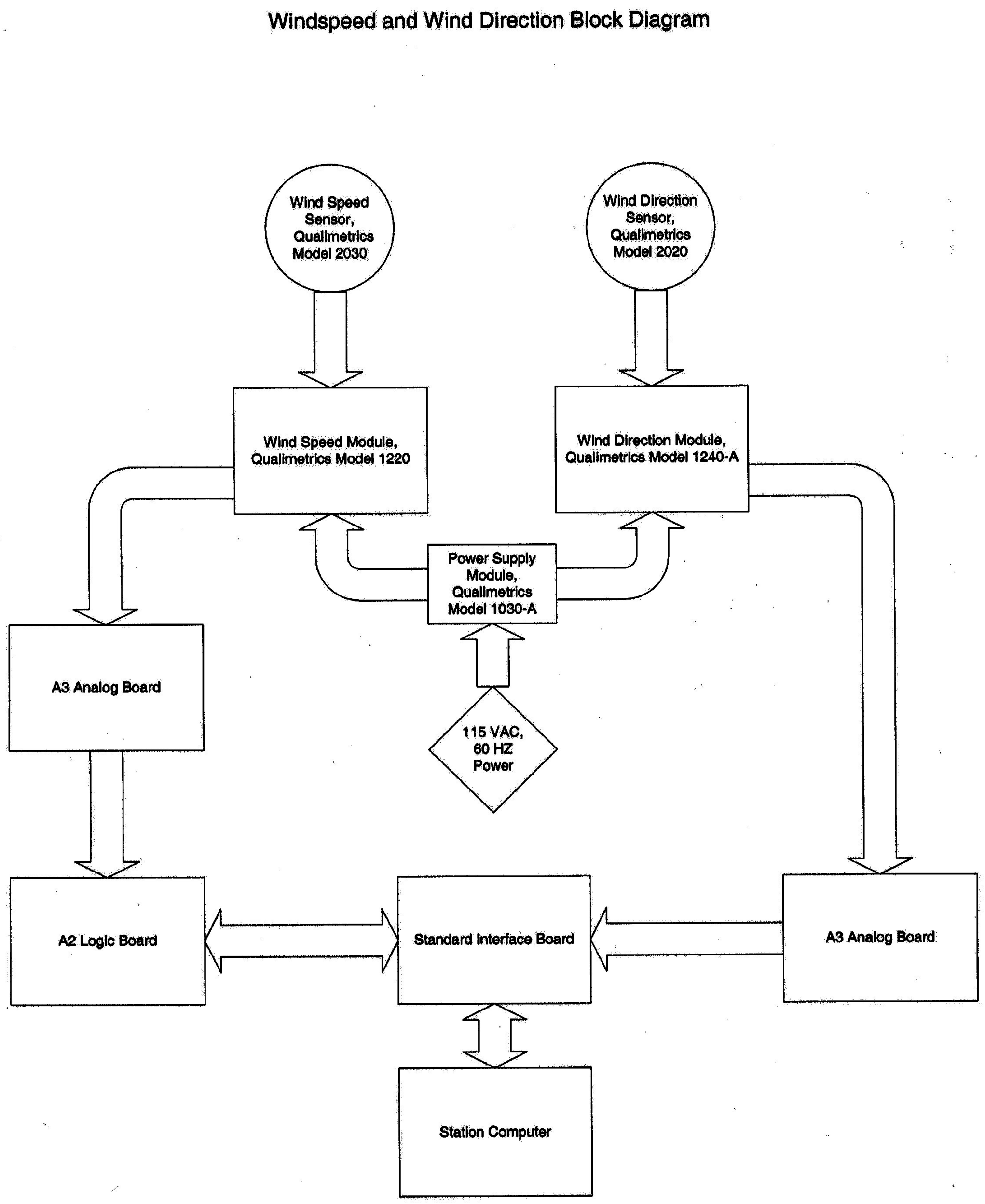


Figure 8 Wind Speed and Wind Direction Block Diagram

Rain Gauge

Precipitation in the form of rain or snow is measured with the Qualimetrics Model 6021-B Electrically Heated Rain and Snow Gauge. These gauges are designed for corrosion resistance, and have a built-in level for proper installation.

This gauge has a tipping bucket with a switch closure. Each tip is equivalent to 0.1mm of depth measured over the surface area of the collection funnel. The gauge can be heated for site locations that usually receive snowfall.

Figure 9 is the Rain Gauge Block Diagram, however refer to Appendix 2 for further information and specification for the rain gauge.

Plate 4 illustrates the rain gauge and its mounting assembly.

Rain Gauge Block Diagram

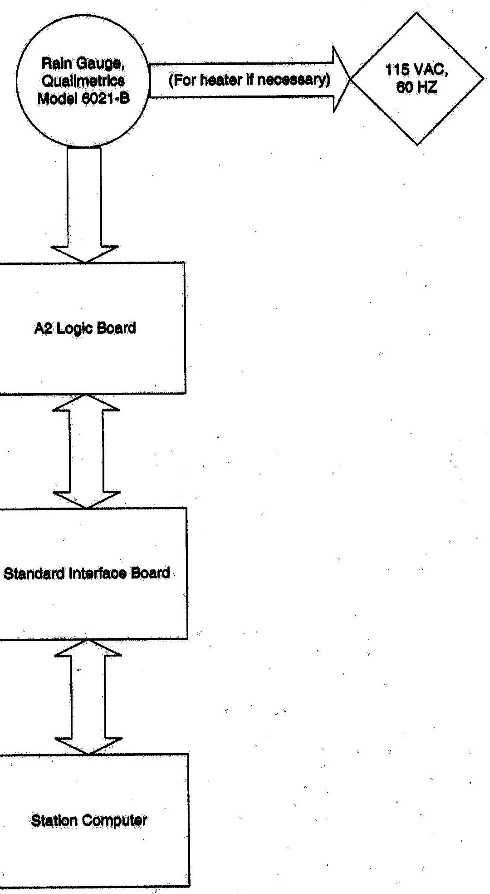
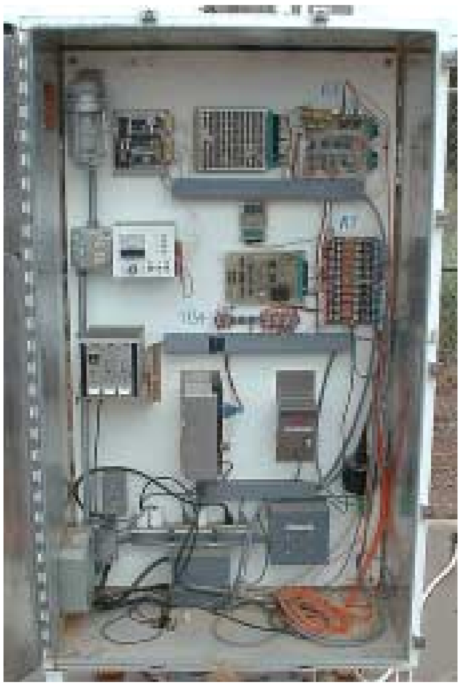


Figure 9 Rain Gauge Block Diagram

Panel Mount Assembly Descriptions

Plate 5 illustrates the panel mount assembly and associated components inside the electronics enclosure.



A1 Standard Interface Board

The Standard Interface Board is a 6" x 6" x ¾" PC board appropriate for installation in an NRAO module, and is the heart of the communications link from each weather station via a time-serial Monitor and Control Bus. It is the general-purpose monitor and control interface in the VLBA Telescope Monitor and Control System.

The Standard Interface Board sends or receives data from the A2 Logic Board and the A3 Analog Board. The A2 Logic Board implements the command and monitor data functions, device address and decode. The analog signals come from the A3 Analog Board, and are converted to digital form by the Standard Interface Board.

Interconnection between the electronics enclosure to the control building is through a set of fiber optic cables, consequently reducing the risk of damage in the event of lightning strikes or an external electrical source introduced on or near the weather station. Stow signals to the ACU in the antenna pedestal room from the A3 Analog Board is via twisted pair cable.

Figure 10 is the VLBA Weather Station MCB Addressing, A55006W010. It shows the MCB address assignments for the various monitor and control functions of the weather station.

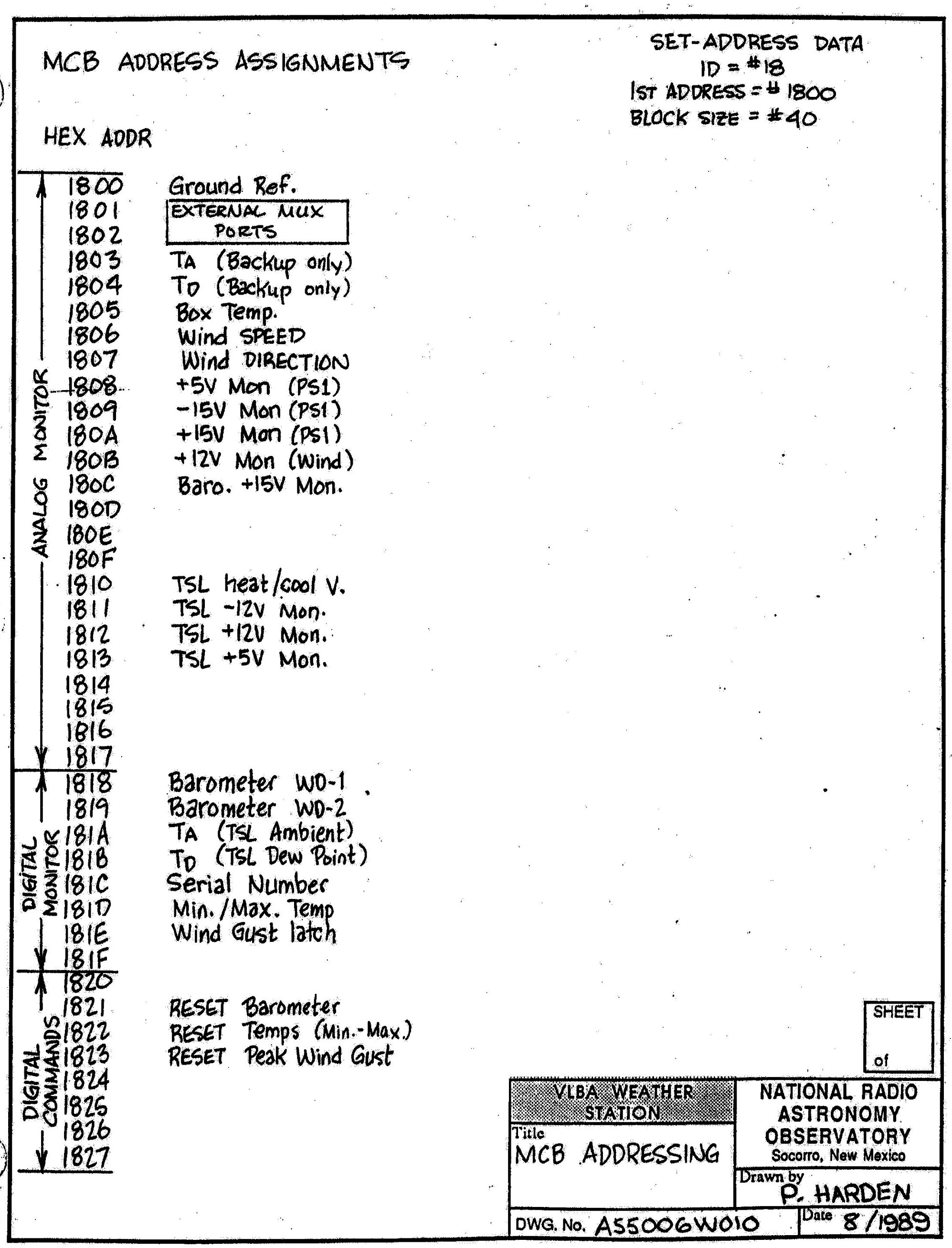


Figure 10 VLBA Weather Station MCB Addressing, A55006W010

A2 Logic Board

The A2 Logic Board is a 6" x 7" wire-wrap board with a 100-pin edge connector. The logic board stores and distributes the digital information furnished from the sensors and their component parts to the Standard Interface Board when requested. It performs a variety of functions including address decoding, digital command and monitor decoding, as well as analog multiplexing to the A/D converter on the Standard Interface Board.

Detailed schematic drawings for the A2 Logic Board are in the theory of operation portion of this manual.

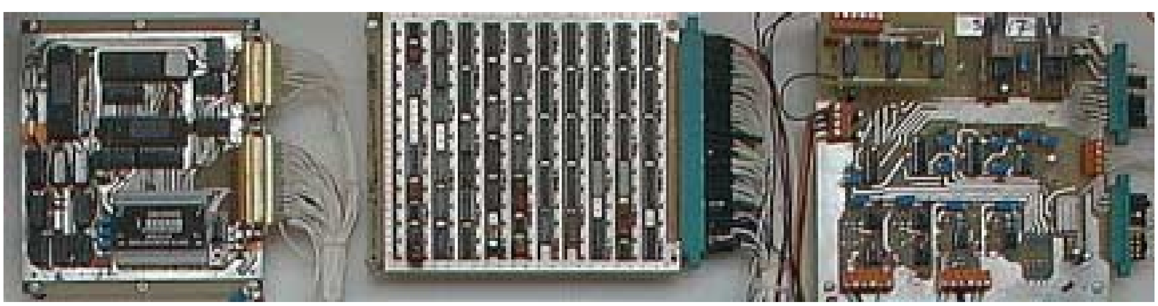
A3 Analog Board

The A3 Analog Board is a 6¾" x 7" PC board with two edge connectors, and an interface to the fiber optic link. It supplies signal conditioning for the ambient and dew point temperatures measured directly from the 10m tower. This is for detecting and setting a low temperature warning for the antenna ACU.

Conditioning for the wind direction and wind speed is provided, as well as warning levels for excessive wind velocities. There is also circuitry for setting the box hot and cold conditions, which turns on either the box fan or heater for moderating the enclosure temperatures.

Likewise, the detailed schematic drawings for the A3 Analog Board are in the theory of operation portion of this manual.

Plate 6 illustrates the Standard Interface Board, the A2 Logic Board and the A3 Analog Board.



A4 Wind Signal Processors

The outputs from the wind speed and wind direction sensors require a bit of signal conditioning. The Wind Signal Processors are a conditioning system that provides for sensor load matching, sensor electrical isolation, as well as calibration and amplification of the sensor signals.

The Wind Signal Processors are housed in a single Signal Conditioning Module File, Qualimetrics Model 1023. It accepts a power supply module and two signal conditioning modules. Input and output signal lines to the modules are on terminal connector blocks located at the rear of the file.

Refer to Appendix 2 for detailed schematics of the wind speed and wind direction sensors and signal conditioning electronics.

Plate 7 illustrates the Wind Signal Processors.

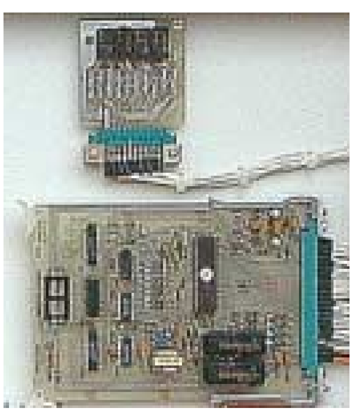
A5 TSL Receiver Board

The A5 TSL Receiver Board is a 5" x 7" PC board with an edge connector. It receives a serial data stream from the TSL located on the 10m-weather tower.

The recorded ambient and dew point temperatures, along with the minimum and maximum temperatures are passed to the A2 Logic Board where they are loaded into data registers and readied for transfer to the Standard Interface Board.

The detailed schematics for the A5 Receiver Board are in the theory of operation portion of this manual.

Plate 8 illustrates the TSL receiver board and display card.



A6 A.I.R. Digital Barometer

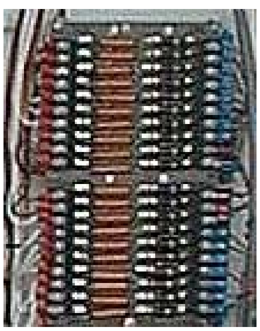
As described in the Sensor Descriptions above, the barometer for the weather station is the Atmospheric Instrumentation Research (A.I.R.) Model AIR-DB-2AX, a microprocessor controlled digital pressure transducer. It measures the atmospheric pressure in millibars.

Refer to Appendix 3 for the detailed schematics and addressing information for the A.I.R. barometer.

A7 Signal Protection Board

The A7 Signal Protection Board is assembled onto a single 5" x 9" PC board, Qualimetrics Model 10643. It bestows protection against surge currents created by lightning or electrical sources external to the meteorological instrumentation, thereby guarding the delicate circuitry located within the electronics enclosure. The circuit board contains components and terminals for 20 input signal lines.

Plate 9 illustrates the A7 Signal Protection Board



Surge protection is offered by self-quenching gas tube arrestors that feature rapid transient response and can withstand high follow currents. A resistor and inductor are used in conjunction with the spark-gap tube and a dual zener diode helps to slow and extinguish surge currents that are below the ionization threshold of the gas tube.

Refer to Appendix 2 for the detailed information of the signal protection board.

A8 Box Heater

The Box Heater for the electronics enclosure is a thermostatically controlled fan-driven unit, and is adjustable from 0°F to 100°F. It is a Hoffman Model A-DAH1001FT. The dimensions are 10½" x 3" x 4", and the housing is anodized aluminum.

The fan draws cool air from the bottom of the enclosure and passes the air over the thermostat and heating elements before being released into the enclosure space. This unit helps maintain stable temperatures inside the enclosure, improving the reliability of the electronics within.

Figure 11 is the VLBA Weather Station “JB2” Temperature Control Circuits Functional Diagram, A55006W009. It is a generalized drawing that shows interconnections for the fan and heater circuits in the electronics enclosure. Also refer to Appendix 5 for more information on the box heater.

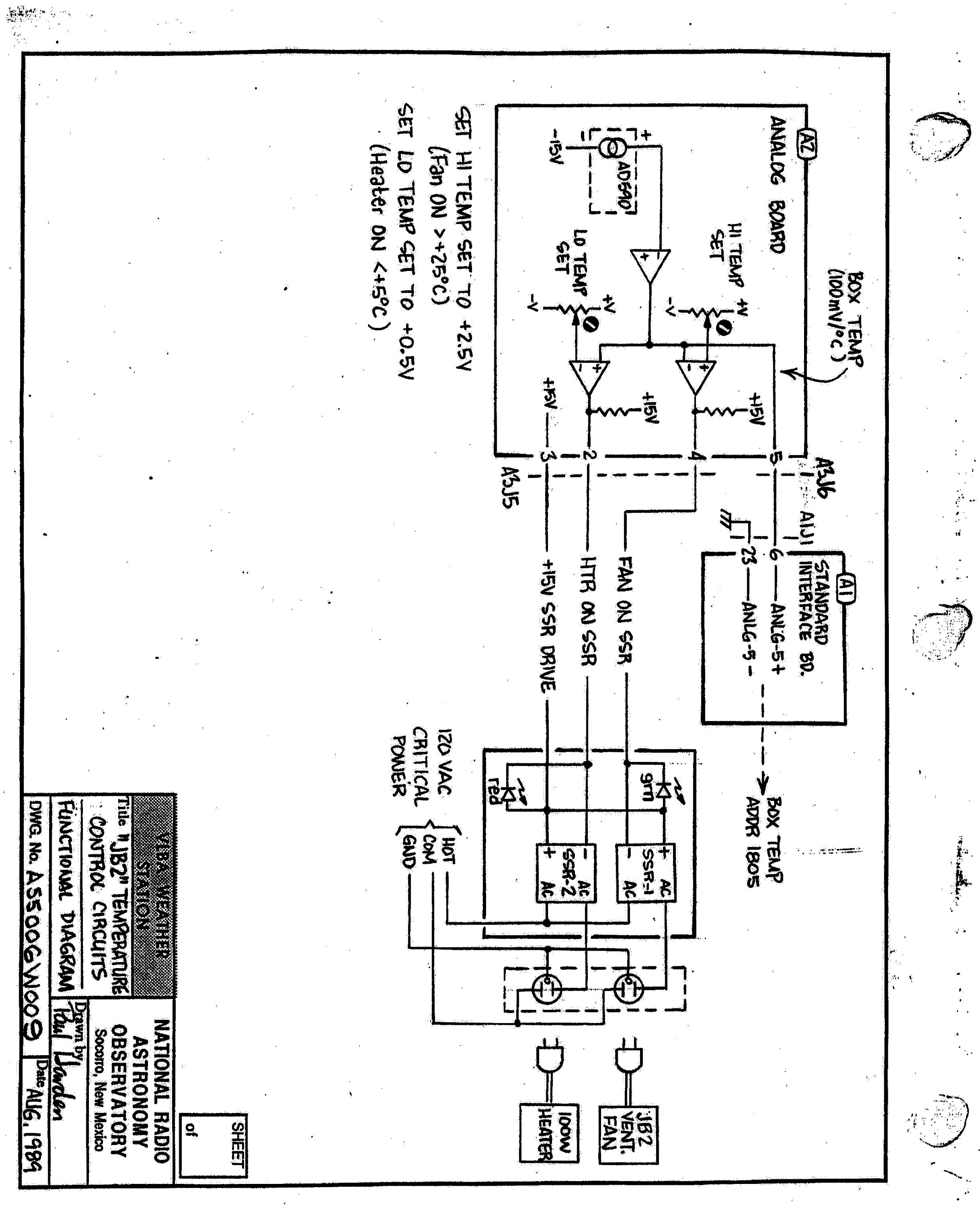


Figure 11 VLBA Weather Station “JB2” Temperature Control Circuits, A55006W009

Plate 10 illustrates the Box Heater.

A9 Data Display Units

The A9 Data Display Units are used to display the ambient and dew point temperatures, the wind speed, the wind direction, as well as +5 VDC. They also monitor the high and low temperatures.

The A9-1 is 6" x 5" x 4" panel mounted chassis that has data transmit LED's that verify data flow from the electronics enclosure via the Monitor and Control Bus.

Interconnection is made to the A9-1 with a 25-pin D-type connector, and the A9-2 is a 3" x 3" PC board with an edge connector. It is a TSL Display Unit PCB, Model 1063-301.

Figure 12 is the VLBA Weather Station Data Tap Ass'y A9-1 Assembly, C55006A009. It is a schematic, assembly drawing and material list for this unit.

Plate 11 illustrates the Data Display Unit.

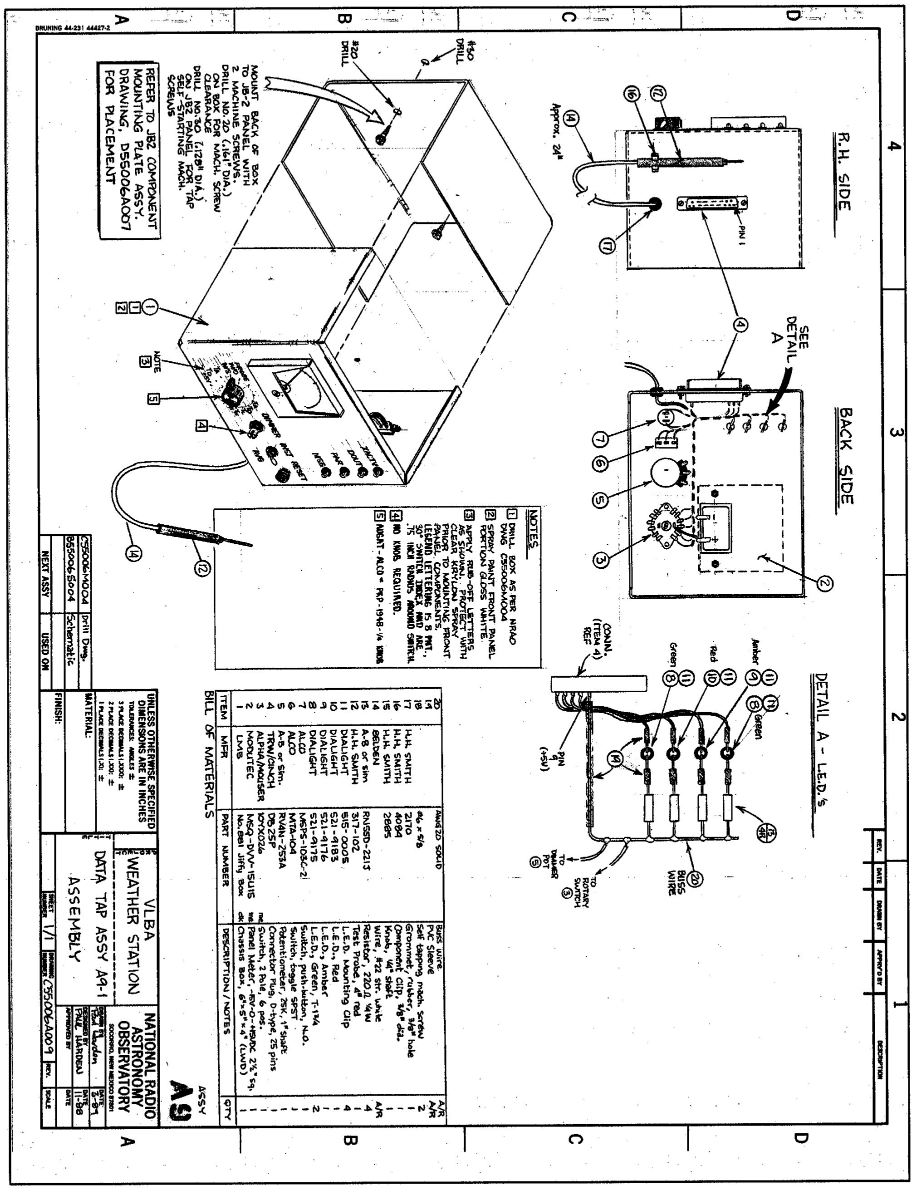


Figure 12 VLBA Weather Station Data Tap Ass’y A9-1 Assembly, C55006A009

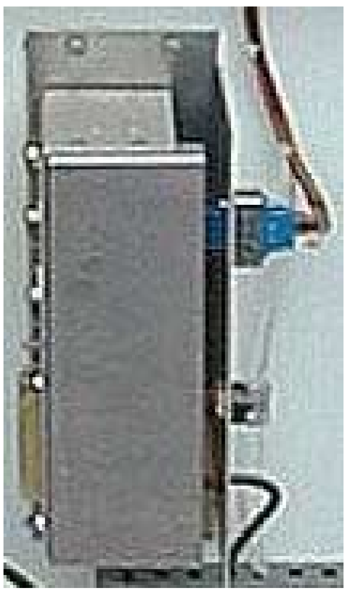
PS1 Power Supply

The Power Supply is mounted on an aluminum-mounting bracket equipped with four captive screws for easy installation and removal on the panel inside the electronics enclosure. The power supply is ACDC Electronics Co., Model ETV-401 triple output DC. It requires 115 VAC power input.

The output voltages supplied are +5 VDC, as well as ±15 VDC. They are connected to the power bus terminal strip via a 14-pin AMP connector plug and socket arrangement, and the power supply is fused on the input side with a 2A, 250V fuse.

Figure 13 is the VLBA Weather Station Assy "PS1" Power Supply Assembly, C55006A006. It is a schematic, assembly drawing and material list for this unit. Appendix 4 contains more information regarding this unit as well.

Plate 12 illustrates the PS1 Power Supply.



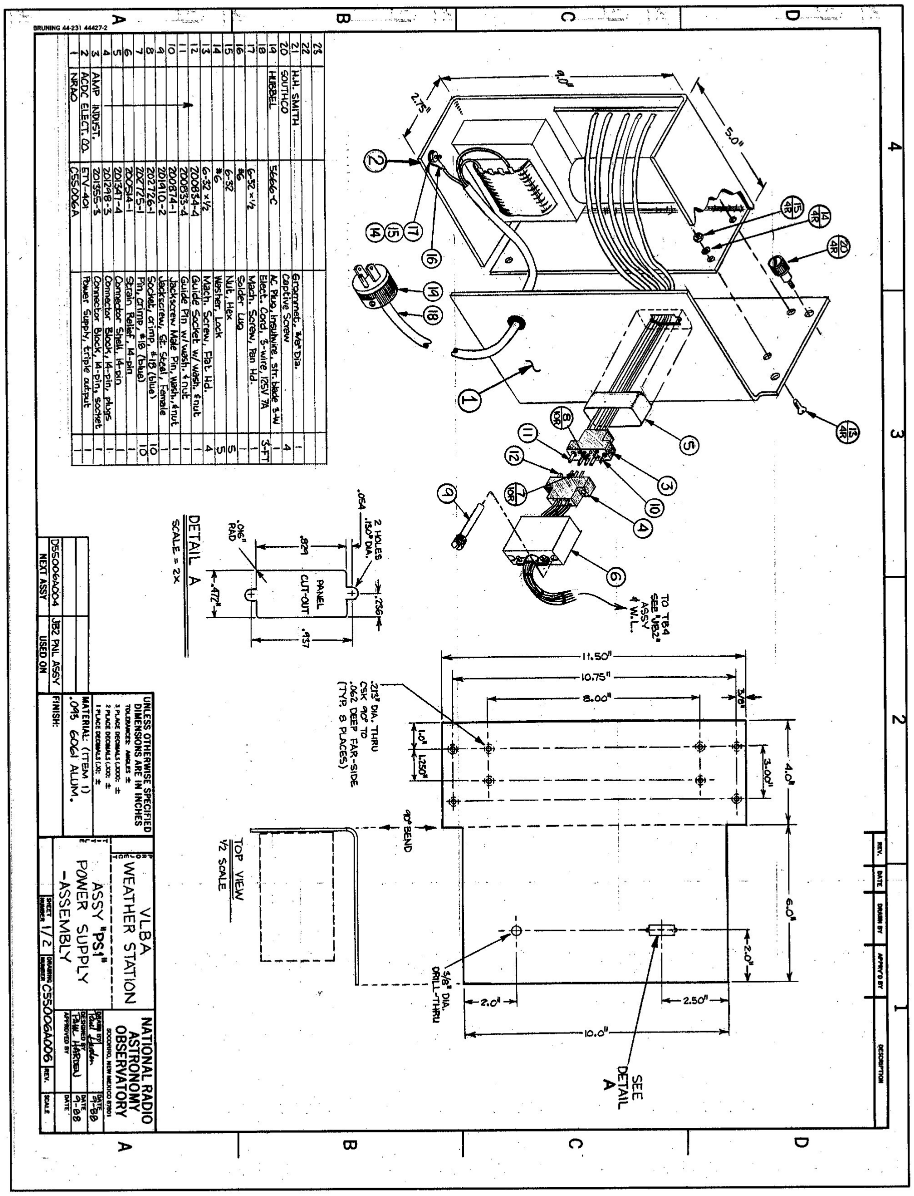


Figure 13 VLBA Weather Station Ass’y “PS1” Power Supply Assembly, C55006A006-1

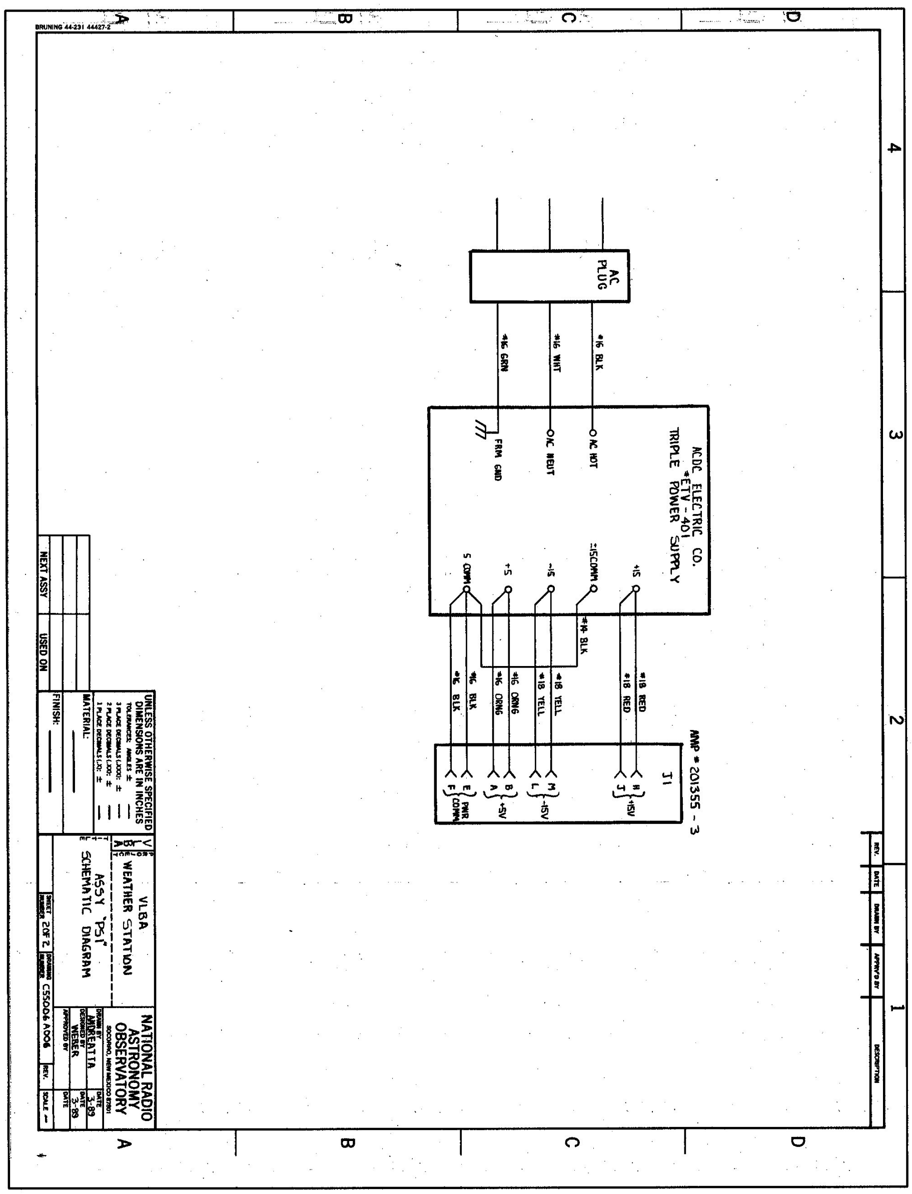


Figure 13 VLBA Weather Station Ass’y “PS1” Power Supply Assembly, C55006A006-2

Additional Hardware Descriptions

AC Power Distribution Assembly

Power for the weather station is 115 VAC single-phase power. There are no circuit breakers or exposed 115 VAC inside the weather station electronics enclosure, however the enclosure is equipped with an AC disconnect switch to shut off all power in the weather station. A single circuit breaker in the control building provides protection. Dedicated AC receptacles inside the electronics enclosure supply interconnection points for various instruments and power supplies. A utility light, switch and power receptacle is furnished inside the electronics enclosure as well.

Plate 13 illustrates the AC Power Distribution Assembly.

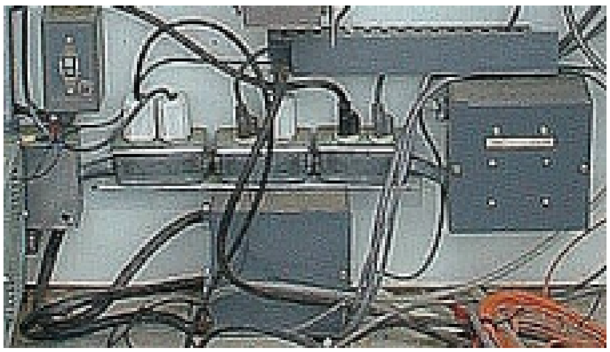


Plate 14 illustrates the utility light, switch and power receptacle.

Figure 14 is the VLBA Weather Station "JB2" Equip Enclosure 120VAC Distribution Wiring Diagram, C55006W001. It is a drawing that shows the interconnections for the AC power at the electronics enclosure.

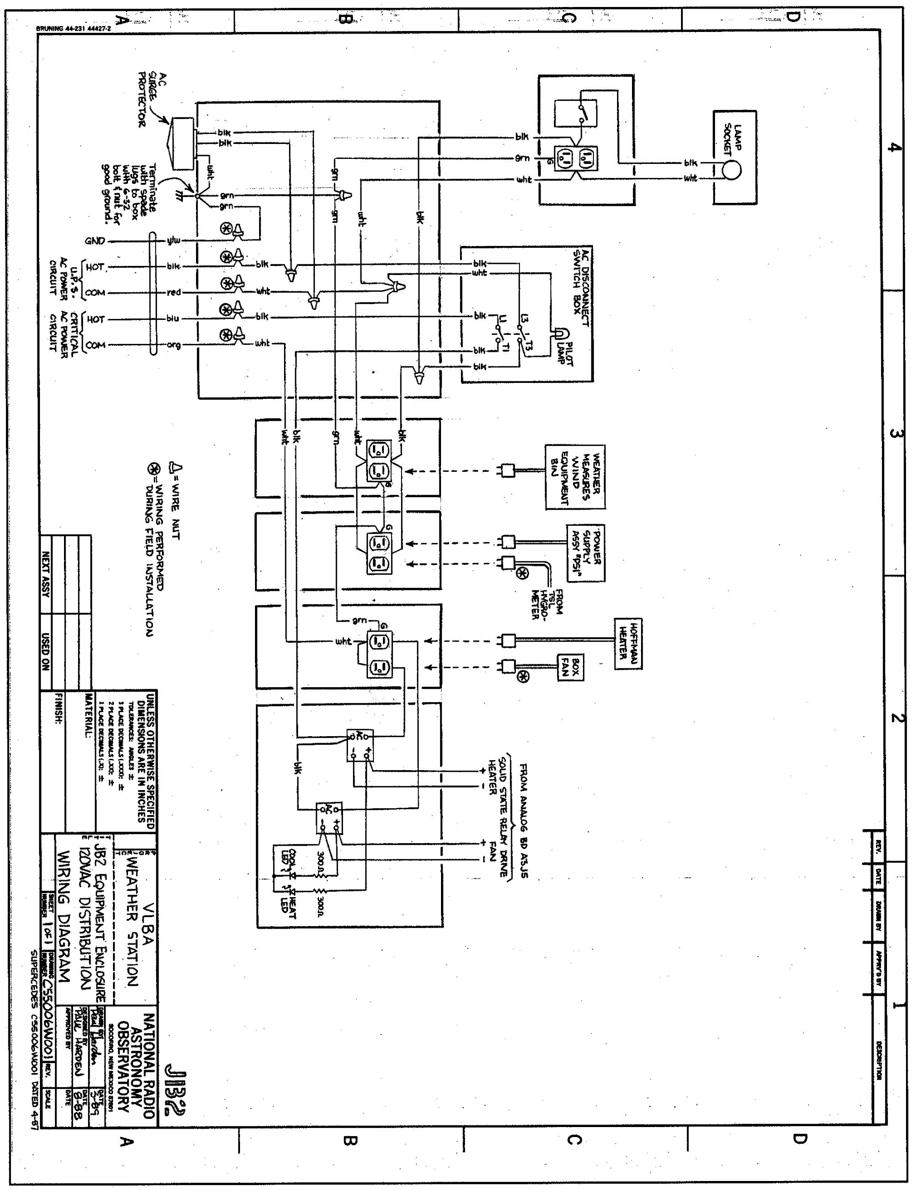


Figure 14 VLBA Weather Station “JB2” Equip Enclosure 120VAC, C55006W001

Enclosure Assembly

The electronics enclosure is similar to Hoffman enclosure type A60H36FLP with a continuous hinged door. This enclosure meets NEMA-4 standards for outdoor use. Outer dimensions are 60" x 36" x 16" for the enclosure. The mounting panel dimensions are 57" x 35". There are ventilation openings located on the enclosure, both equipped with a louver and filter to help keep out contaminants or foreign matter. The lower opening has the ventilation fan mounted therein. Some enclosures have rigid insulation in the interior to help minimize temperature extremes.

Figure 15 is the VLBA Weather Station Equipment Enclosure Mechanical Drawing, C55006M001. It is the mechanical drawing for the enclosure. Figure 16 is the VLBA Weather Station "JB2" Component Mounting Plate Assembly, D55006A007. It is the assembly, layout and part list for the panel mounted assemblies inside the electronics enclosure.

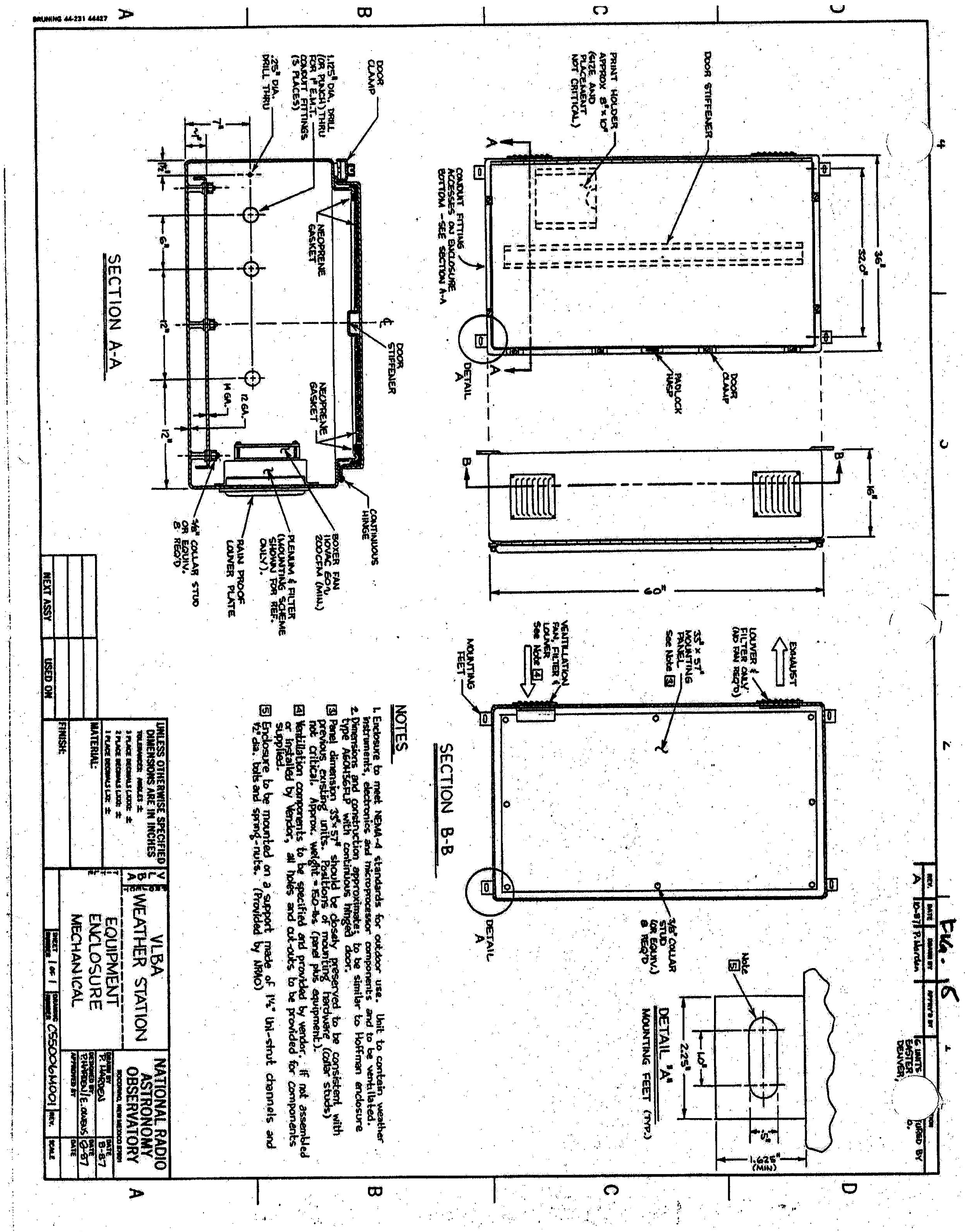


Figure 15 VLBA Weather Station Equipment Enclosure, C55006M001

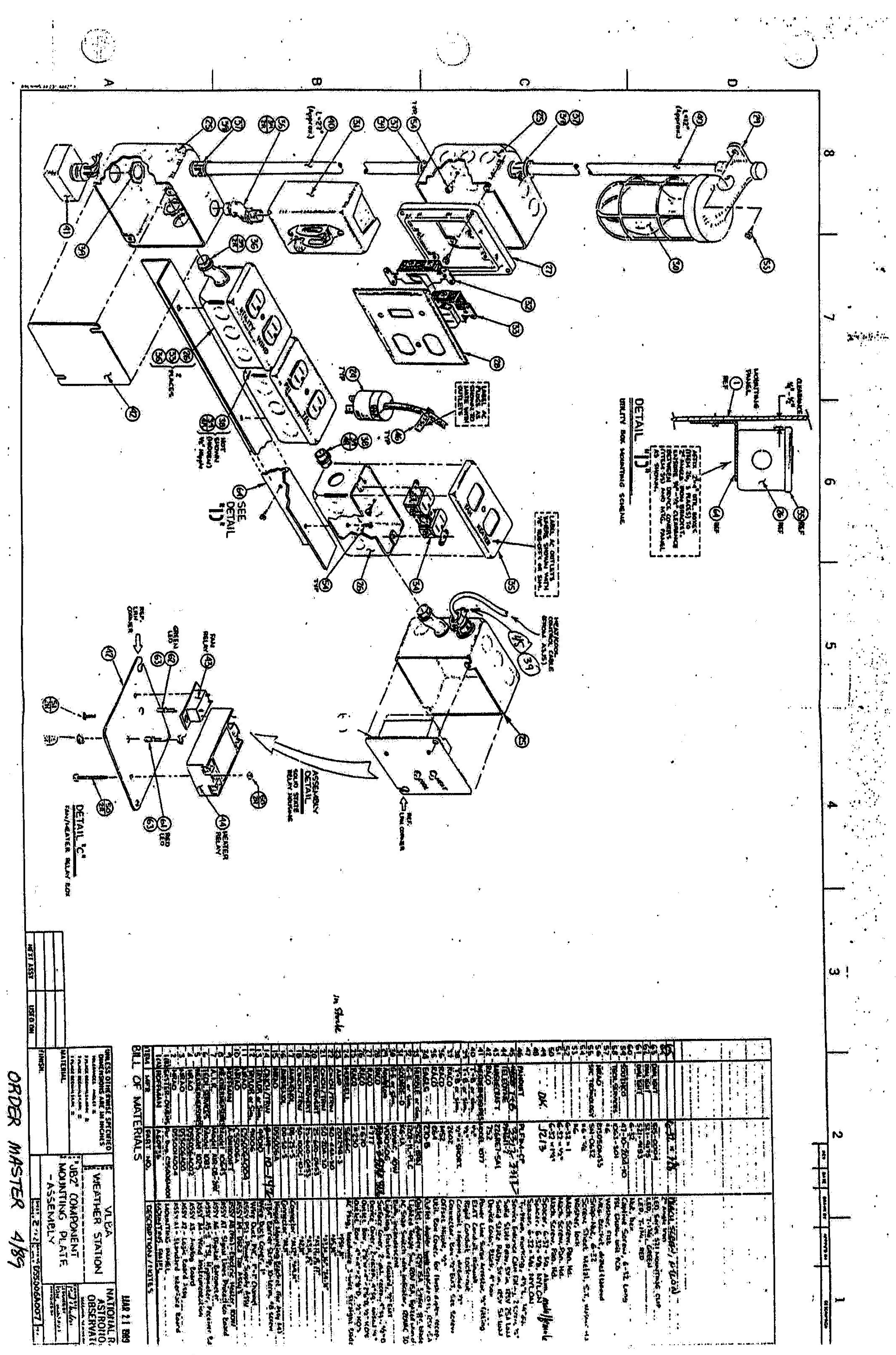


Figure 16 VLBA Weather Station “JB2” Component Mounting Plate, D55006A007-1

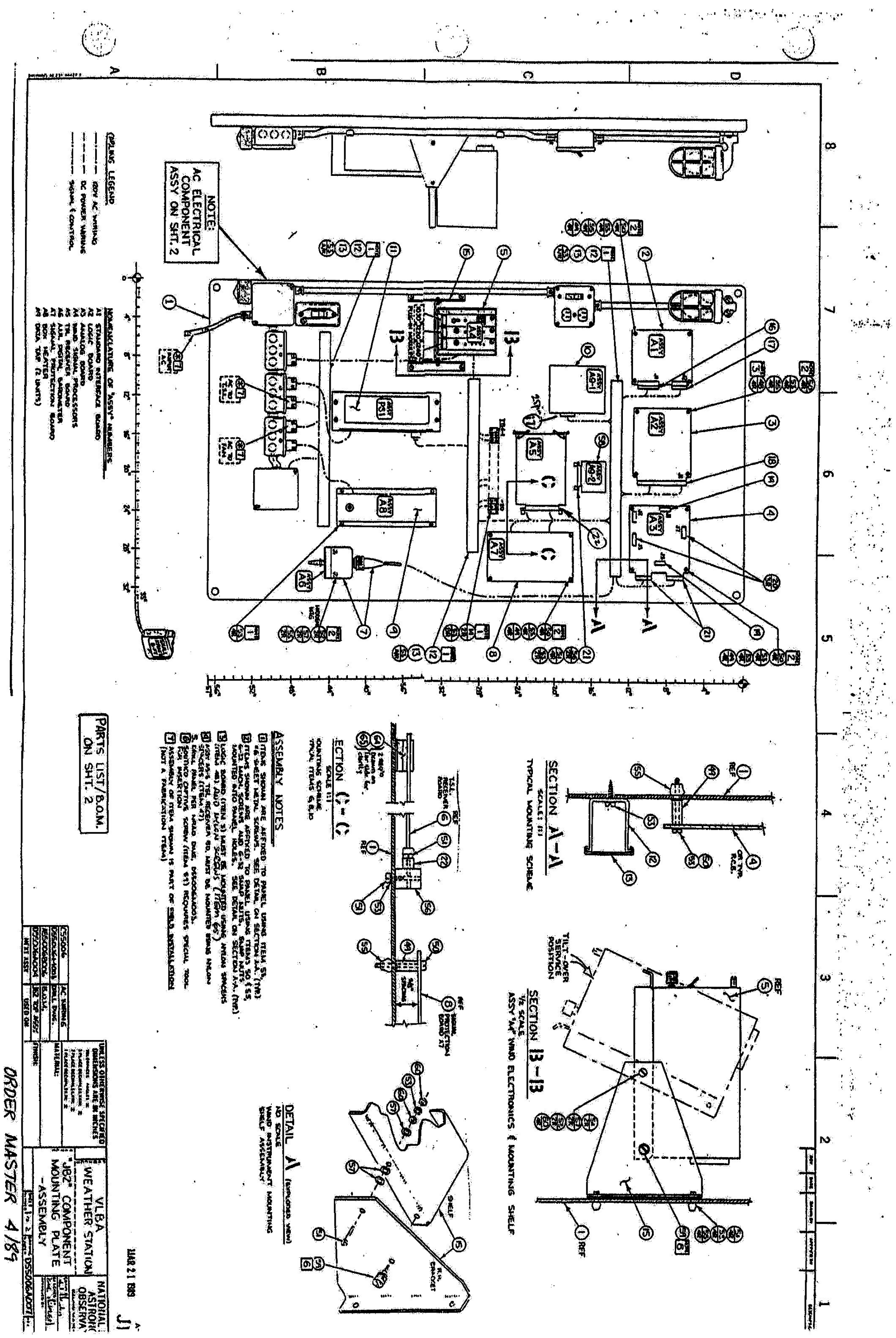


Figure 16 VLBA Weather Station “JB2” Component Mounting Plate, D55006A007-2

Fan Assembly

The fan assembly is a 115 VAC 60 HZ boxer fan mounted with a bracket in proximity to the lower ventilation opening on the enclosure. The airflow from the fan is 200-CFM minimum.

There are no drawings for the fan assembly, however Plate 15 illustrates the fan assembly inside of the electronics enclosure.

Plate 16 illustrates the ventilation opening on the enclosure.

Plate 17 shows the upper ventilation opening.

Miscellaneous Assembly

The 10m tower for the weather station is a Rohn Model 25G fold-over tower, and has a base mount adapter plate ensconced firmly into a concrete pad. There is a hand-crank to raise and lower the tower for servicing the instruments mounted atop the tower

Plate 18 illustrates the hand crank mounted on the tower.

A cross-arm for mounting the wind direction and wind speed sensors is the Qualimetrics Model 2023, and mates with the mast on the tower. The tower lightning rod ground and electronics enclosure ground cables are cad-welded to the ground rods. Tower guy wires are also grounded.

Plate 19 shows guy wire and turnbuckle hardware.

Figure 17 is the VLBA Weather Station Site Installation Drawings, C55006A008. It shows the tower installation and electronics enclosure. Figure 18 is the VLBA Weather Station Rohn Tower Adapter Plate, C55006M002. It is the adapter plate for the tower.

Plate 20 illustrates the concrete pad, adapter plate and grounding for the tower.

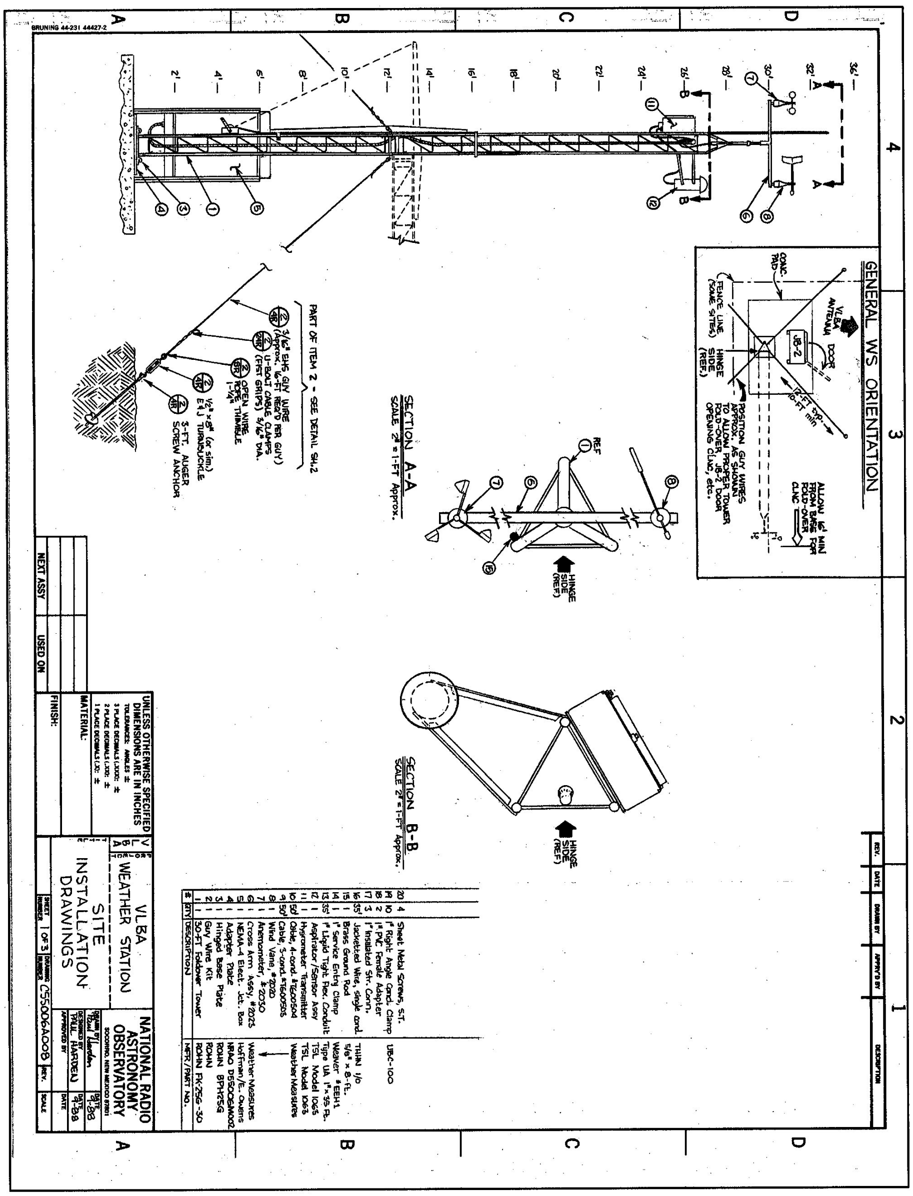


Figure 17 VLBA Weather Station Site Installation Drawings, C55006A008-1

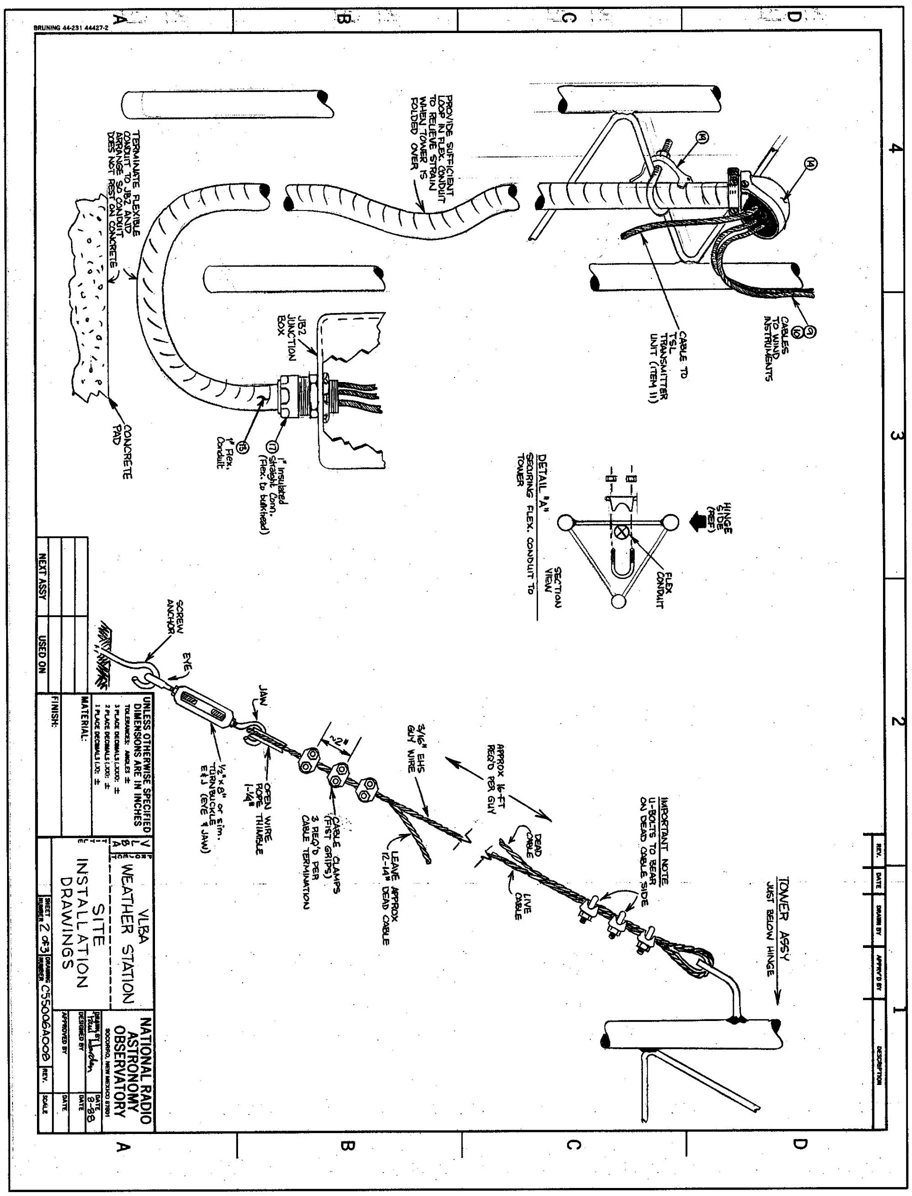


Figure 17 VLBA Weather Station Site Installation Drawings, C55006A008-2

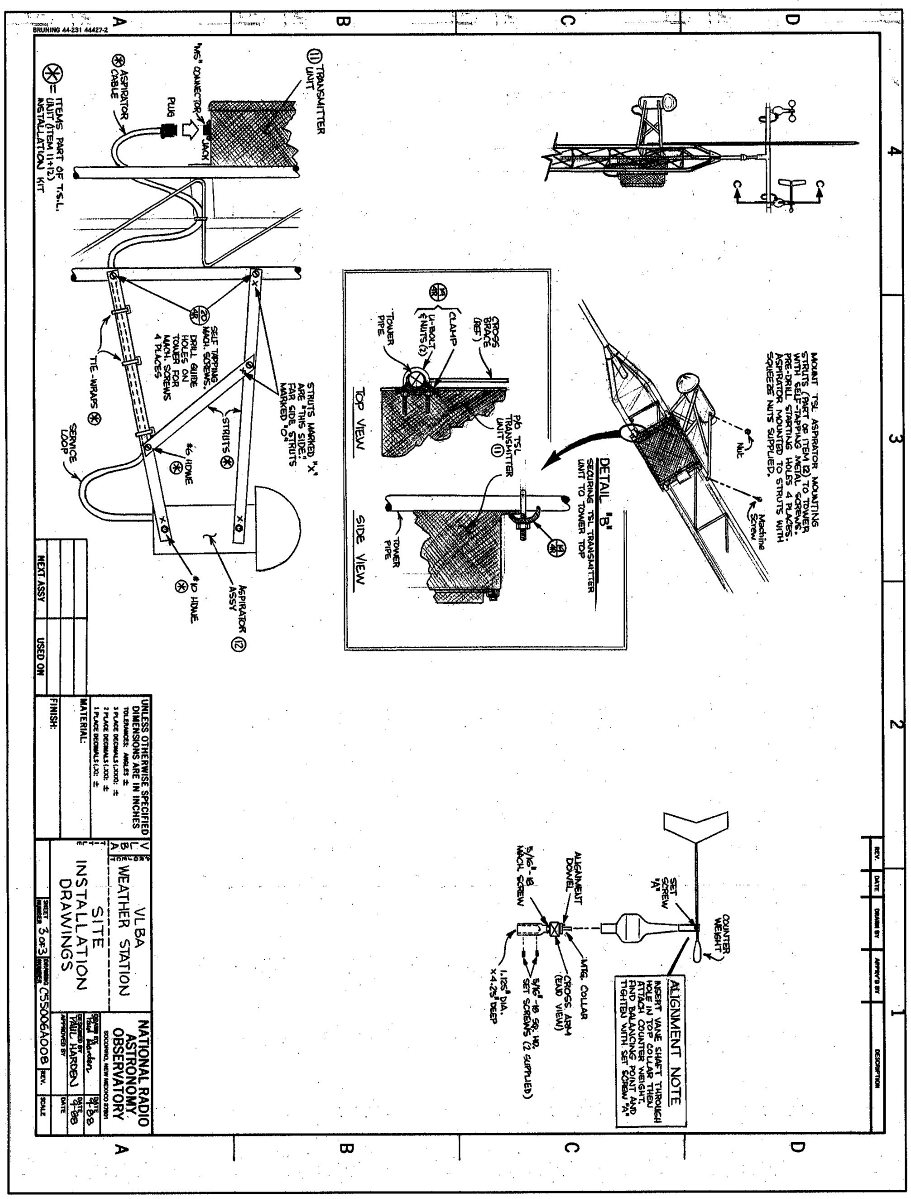


Figure 17 VLBA Weather Station Site Installation Drawings, C55006A008-3

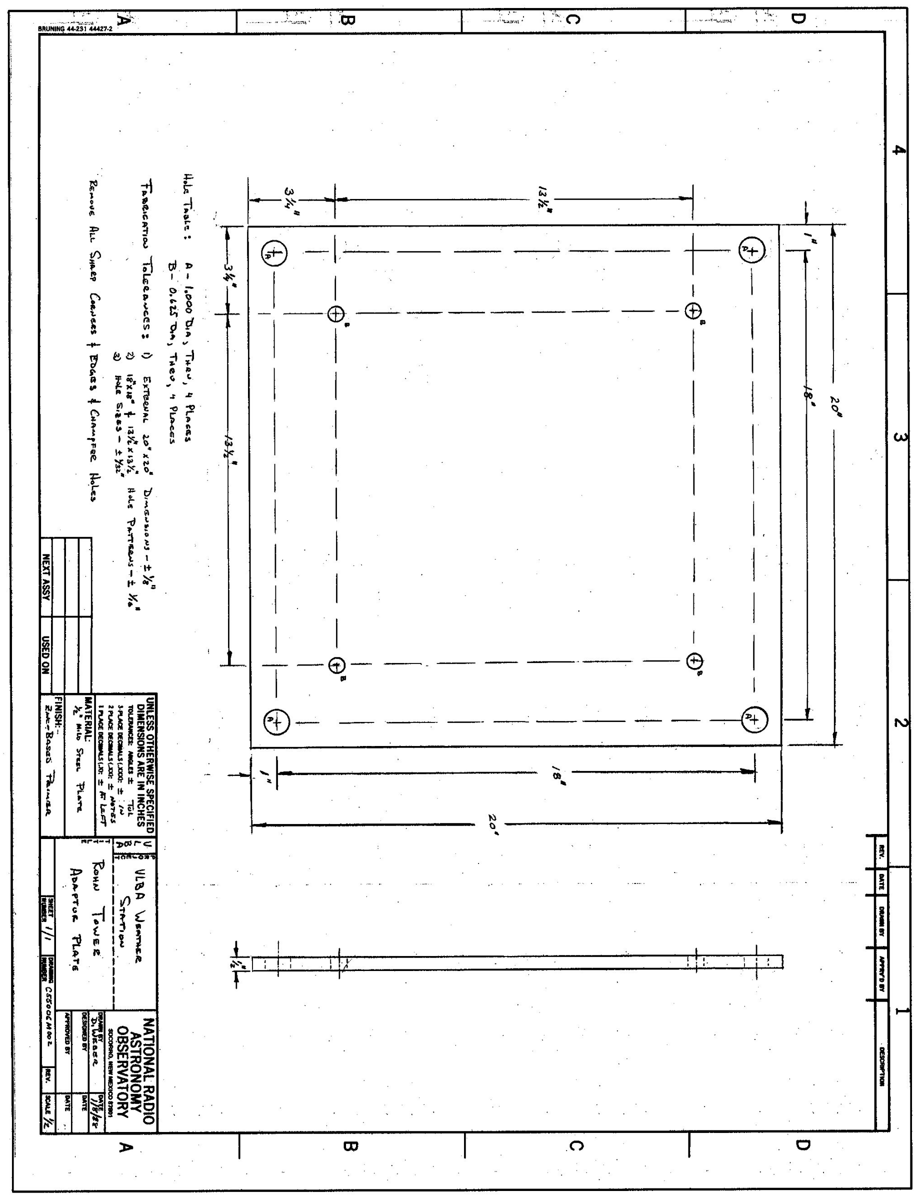


Figure 18 VLBA Weather Station Rohn Tower Adapter Plate, C55006M002

Theory of Operation

TSL Model 1063 Hygrothermometer

This section was excerpted directly from the manual for the TSL. The comprehensive manual is in Appendix 1 of this manual. The TSL has several separate functional areas, including the thermal control loop, temperature measurement, data management, analog to digital conversion, data multiplexing, data transmission, data receiving, data processing, and data display.

Figure 19 is the VLBA Weather Station TSL Transmitter Card Schematic Diagram, C55006S010. It is the detailed electronic schematic for the TSL, and should be referred to for troubleshooting and analysis purposes.

First the thermal control loop is considered. Figure 3-1 in Appendix 1 graphically illustrates the elements of the feedback loop that maintains the mirror at the dew point temperature. This is the heart of the TSL.

A beam of light from a small LED, CR1, is directed at the surface of a mirror at an angle of 45 degrees. Two phototransistors, Q1 & Q2, are mounted to receive the reflected light as shown. Q1, the "direct" sensor, is placed so that it receives light when the mirror is clear. Q2, the "indirect" sensor, is located so that it is sensitive to light that is scattered when the mirror is clouded with visible condensation. As the amount of cloudiness of the mirror surface increases, Q1 receives less light and Q2 receives more light.

The feedback loop is closed by condensation forming on the mirror. This occurs from cooling provided by the thermal module. When the unit is first turned on, the mirror is clear and photosensor Q1 receives directly reflected light, and Q2 receives no scattered light. This condition causes a large negative unbalanced signal at the output of U6B, causing a heavy current to flow through the thermal module in the cooling direction. The unbalanced condition remains, typically for about one minute, until the mirror surface temperature has reached the dew point temperature. At the dew point, the output of Q1 decreases and the output of Q2 increases because of the visible effect of condensation on the mirror. The system now stabilizes at the dew point temperature, maintaining just enough cooling effect to keep the signal levels from Q1 and Q2 in balance, with U6B and the power amplifier supplying just enough cooling current to maintain the mirror temperature at the dew point. If the dew point of the air should change, or if the circuit should be disturbed by noise, the loop makes the necessary corrections to re-stabilize at the dew point. The system is designed for continuous operation.

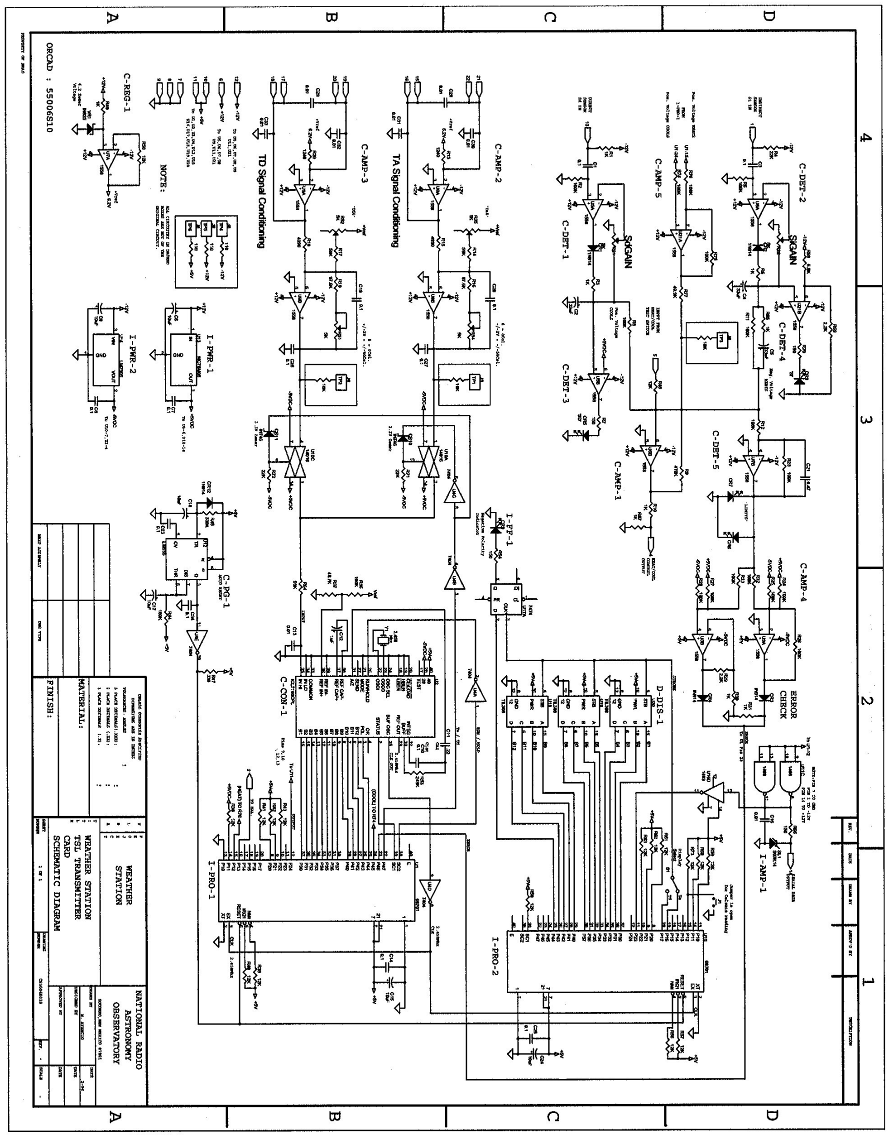


Figure 19 VLBA Weather Station TSL Transmitter Card Schematic, C55006S010

Following Q1 & Q2 are a set of identical signal amplifier-detectors, U5A & U6A, that drive a differential control amplifier, U6B. The output of this hi-gain amplifier is negative when the mirror is clear, and positive when the mirror is heavily clouded, because of the positive difference between the outputs of Q1 & Q2. The output of U6B, through a power amplifier drives the mirror-cooling module, U1. This device is an electronic heat pump, operating much like a thermocouple in reverse. With a DC voltage applied across the terminals, the module produces a temperature difference between its upper and lower surfaces. Depending on the polarity of the applied voltage, the thermal module can heat or cool.

The simplified circuitry described above is the core of the hygrothermometer. All that remains to make this a useful instrument is a means of measuring and displaying the mirror temperature.

Two temperatures are measured, the ambient (Ta) and the dew point (Td). The measurement circuits for the two channels are identical. Figure 3-2 in Appendix 1 illustrates all the circuitry involved in producing two output DC voltage levels which precisely represent Ta and Td. The basic sensor for temperature measurement is a platinum wire resistor called an RTD, for Resistance-Temperature Device. This sensor is encased in a ceramic cylinder, about 1/8 inches in diameter and ¾ inches long. At a temperature of 0ºC, the RTD has an electrical resistance of exactly 100 ohms. The resistance varies linearly with temperature, at a rate of .392 percent per degree C.

In our application, a constant DC current of 5 mA flows through the RTD, and the resulting voltage drop across the sensor is used as the temperature signal. In the Ta channel, amplifier U8A is used as the constant 5-mA source through the RTD. The RTD in this example would be located in the stream of air entering the aspirator unit, so that it would assume the temperature of the ambient air. U8B is used as a scaling and offset adjustment amplifier, setting the output voltage level at a convenient value.

Two DC currents feed the node of U8A, a 5 mA reference input from a 6.2 volt reference voltage source through a precise 1240 Ω resistor, and a feedback current of opposite polarity equal to U8A output voltage through the RTD. By standard operational amplifier analysis, one can see that the feedback loop will force the feedback current to be equal to the 5-mA input current. Since the node of the op-amp, pin 1, is at virtually zero, the U8A output voltage must be equal to .01 x R1 volts. This would give us an output voltage equal to -.5 volt DC at 0°C, -0.4 volts an output voltage equal to -.5 volt DC at 0°C, -0.4 volts at -50°C, and -.6 volts at +50°C. These values could be used directly for measurement and display purposes, however, they are amplified, inverted and offset by U8B to a more convenient scale. U8B is a conventional inverting op-amp with a gain factor of 20 by virtue of the ratio of the feedback resistance, R34 and R16, and the input resistor, R15. The gain, or scale factor, is slightly adjustable by varying the setting of R34. This is used as a calibration adjustment. The input offset value (-0.5 volt at 0°C) is cancelled out by the signal through R35 and R14. Potentiometer R35 is adjusted to bring the output of U8B to zero at 0°C. At the output of U8B, the signal level vs. temperature relationship is 25°/volt, with 0 volts representing 0°C. A temperature of plus or minus 50°C would be represented by plus or minus 2 volts DC at the output.

The dew point temperature measurement channel is identical in all respects, except that the dew point RTD is physically located inside the body of the mirror, so that it assumes the temperature of the mirror, which is constantly held at the dew point temperature.

In a simpler hygrothermometer system, the outputs of U8 and U9 could be connected to a pair of voltmeters and the system would be complete. The Model 1063 has been designed for capability of displaying the outputs at a great distance from the sensors, so a means of transmitting the outputs must be provided which is insensitive to the effects of line length, noise and other sources of errors.

In addition to transmitting the two analog temperature signals to remote indicators, certain other operations are performed on the data. Among these are detection and storage of maximum and minimum temperature values and averaging the data to eliminate short-term variations. Because of the complexity of circuits that would be required for these operations, microprocessors are used for all of the necessary data manipulations. In the transmitter unit, the two analog signals, Ta and Td, are converted to binary digital words and fed to the input of a microprocessor (MPU). This MPU is used only as a formatting device, converting the input data into a serial format suitable for transmission over long distance telephone equipment. In our case, the data is transmitted from the top of the 10m tower to the electronics enclosure. In the receive unit, another similar MPU receives the data words and performs all of the necessary arithmetic operations and re-formats the data for output display on numeric panel indicators. As an incidental function, the MPU's also perform data quality checks as a safeguard against effects of detectable errors, noise and component failures.

A single analog to digital converter (A/D), type 7109, is used for the Ta and Td data, so a means must be included for time-sharing or multiplexing the converter input. The multiplex gates and A/D converter connections are shown in Figure 3-3 in Appendix 1.

Two CMOS gates are used to selectively connect Ta and Td to the input to the converter. The gates are, in effect, series switches, each controlled by a select line. When the control line to a gate is in the low (0) state, the gate has an effective resistance of hundreds of megohms to the signal. When the control line is high (+5v), the gate presents a resistance of about 50Ω, connecting the signal to the converter. The two gate outputs are tied together, and their control inputs are complementary, so that at any given time only one of the two inputs is connected to the converter.

Operation of the converter is automatic, as described by the 7109 data sheet. When the RUN/HOLD line from the MPU to the converter is in the RUN condition, the analog input controls the generation of a parallel 12-bit binary representation of the input quantity. The 11 data bits and polarity bits are hard wired to appropriate inputs of the MPU.

Conversion requires about 30 milliseconds, depending on the data value. To prevent data transfer to the MPU occurring during the conversion time, a STATUS line from the converter is used as a signal to indicate to the MPU that data is stable and available after each conversion. When the STATUS line is high, the MPU may request new data values. Likewise, after the MPU has processed an input data word, it raises the RUN/HOLD line to signal the converter that a new conversion may begin. This exchange of control signals is called a "handshake" process.

After the MPU has processed an input sample, it reverses the state of the multiplex control line to the analog gates. If the data sample had been Ta, the next condition of the control line would be to enable the Td gate, and vice versa.

In the MPU, the data words Ta and Td are temporarily stored and formatted into a low-speed serial output train. A 1488 RS232 line driver is used to buffer the MPU output signal for transmission. Transmission is by way of a 600 baud Manchester code, suitable for conventional telephone-grade circuits. The data is otherwise unchanged by the transmitter data handling circuits.

Figure 20 is the VLBA Weather Station Receiver PCB Logic Diagram, C55006L002. It is the detailed electronic schematic for the TSL receiver, and should be referred to for troubleshooting and analysis purposes.

In the receive unit, the serial data stream is buffered by a type RS232 1489 line receiver and fed directly to the serial input data port of the MPU. Although data flows continuously into the MPU at a rate of 2.5 complete frames/second, the MPU uses the input data only once per 37.5 seconds. When the MPU begins its input process, it examines the Ta and Td values. If Ta or Td is more than 2 degrees different from the presently displayed value, the data is considered to be faulty, and the sample is discarded, and the next sample is tested. This process is repeated for three trials. At the fourth trial, the data is accepted unconditionally. This tends to screen out errors that may be caused by momentary signal transients or transmission line faults. The data that is accepted is stored in the MPU memory. Figure 3-4 in Appendix 1 illustrates the flow of data in the receiver unit.

All of the data processing described so far has served only to enable the transmission of the raw data, unchanged, to the receiving display unit. Before the Ta and Td values are displayed, certain manipulations and calculations must be made. These are all performed by the MPU in the receive unit.

The received data, after the input screening for obvious errors, is stored in memory. This process occurs at 37.5-second intervals. Memory space is reserved for 8 complete samples of Ta and Td, representing 5 minutes of climate conditions. The 8 sample values are added and divided by 8 to yield a 5-minute average value of Ta and a 5-minute average of Td. The average values are updated at each 37.5-second input sampling and stored in memory.

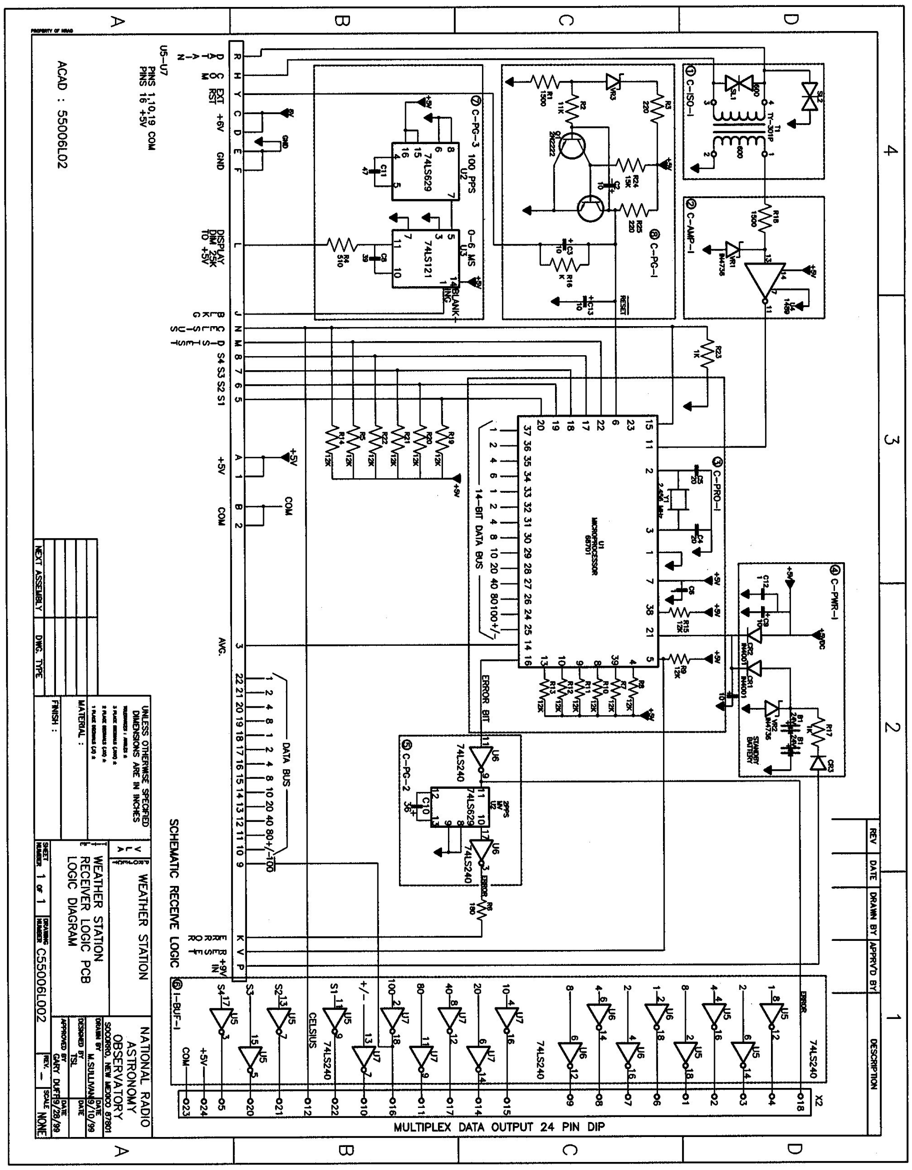


Figure 20 VLBA Weather Station Receiver PCB Logic Diagram, C55006L002

At each updating, the value of average Ta is examined and compared against a stored maximum and minimum value. If the average Ta is greater than Tmax or less than Tmin, the max or min value is changed accordingly. Tmax and Tmin are maintained continuously, and are re-started by way of a reset command.

To prepare the output data words for display, the 11-bit binary numbers in storage are converted to Binary Coded Decimal (BCD) format. This is done by a subroutine in the MPU program. All of the output data are brought out of the MPU on 14 lines, coded as tenths, units, tens, and hundreds of degrees and a polarity bit.

The display module in the electronics enclosure contains storage latches to sample and store the data as it is strobed in. The latch modules, type MC14511, also contain seven-segment decoder-drivers that directly drive the incandescent segments of the decimal display.

Wind Speed Sensor

The wind speed sensor is a Qualimetrics Model 2030 anemometer. It uses three cups, and utilizes a photon-coupled chopper to produce a pulse output with frequency proportional to wind speed. The threshold of this anemometer is 0.5 miles/hour. The complete assembly, with exception of the photon coupled chopper, is manufactured from stainless steel. It is connected with cabling with a quick release waterproof connector. This anemometer is used in conjunction with signal conditioning modules that provide an analog signal output proportional to the wind speed.

The photon-coupled chopper consists of two parts. A light emitting diode in combination with a light sensitive transistor is mounted directly to the anemometer connector. A slotted wheel connected to the anemometer shaft interrupts the light beam between the light emitting diode and the photon transistor. This interruption of light causes a change in the transistor collector to emitter current. The changes in current are amplified and conditioned in the signal conditioning modules to provide an analog signal proportional to frequency.

Wind Direction Sensor

The wind direction sensor is a Qualimetrics Model 2020 vane. It is an analog output wind vane, and is equipped with a structural plastic tail with a durable aluminum filled plastic coating. The vane body is a precision-machined aluminum housing with a clear anodized finish. Stainless steel shafts bearings and fittings are used throughout. A precision potentiometer is coupled to the vane shaft to provide an analog output proportional to wind direction. An airfoil style counter-weight provides precision balance of the tail assembly upon the shaft. A quick release waterproof connector is provided for cable terminations.

Changes in the wind direction are sensed mechanically by a balanced vane assembly. The mechanical motion is transformed into an electrical signal through a shaft that couples the vane to a potentiometer.

The potentiometer used in the wind vane has a long electrical angle and is a make-before-break 5000Ω resistive element. The actual element is a wire wound device to help increase the life of the sensor.

Protective zener diodes are attached across the excitation lead and the wiper lead to the common lead. The diodes help quench transients induced by external sources.

The potentiometer is excited by a +5 VDC regulated source. A 2500Ω resistor is placed in series with the +5 VDC source to protect the source when the make-before-break contact occurs and to protect the potentiometer element against a dead short in the +5 VDC power source. The voltage generated at the potentiometer wiper varies from 0 to 3.333 VDC as a direct function of the wind direction variations.

Rain Gauge

The rain gauge is a Qualimetrics Model 6021-B Electrically Heated Rain and Snow Gauge. It is a tipping bucket rain gauge. Rain enters the gage through a large funnel, the rim of which is protected by a metal ring to prevent distortion. Collected water passes through a debris-filtering screen and is funneled into one of two tipping buckets inside the gage. The bucket tips when a given amount of water has been collected, the amount is determined by gauge calibration.

When precipitation occurs in a frozen form, it is necessary for the heater to be used. Each gauge includes 4 separate heaters. A NiChrome wire heater wraps around the collection funnel to melt the precipitation for measurement. A second NiChrome wire heater warms the internal components and the gage base to prevent re-freezing of the water inside the gage. Additionally, a cartridge heater is plugged into each of the gauge drain tubes so that the measured precipitation passes out of the gauge freely without freezing on contact with the cold outside air. Thermostats control the funnel and the base heaters; the drain tube heaters are continuous duty. Either 115 or 230 VAC can be used as input power.

As the bucket tips, it causes a 0.1-second switch closure. The tip also brings a second bucket into position under the funnel, ready to fill and repeat the cycle. After the rainwater is measured, it drains out through tubes in the base of the gage. The drain holes are cover by screens to prevent insect entry.

The rain gauge is calibrated to a resolution of 0.1mm. As the bucket tips, it causes a magnet to pass over a mercury-wetted reed switch, closing the switch momentarily. Measurement accuracy is 0.5% at a precipitation rate of 0.5 inches per hour.

A1 Standard Interface Board (SIB)

This is a brief overview from VLBA Technical Report No. 12, VLBA Standard Interface Board Manual. For a comprehensive, detailed discussion of the Standard Interface Board, please refer to this manual.

Figure 21 is the VLBA Standard Interface Board Model D Schematic, C55001S004. This is a detailed electronic schematic for the SIB. Refer to this drawing for troubleshooting and analysis purposes.

The Standard Interface Board is used as a general-purpose monitor and control interface in the VLBA Telescope Monitor and Control System. The VLBA Station Computer is the system Controller in this system. The Controller communicates with Standard Interface Boards installed in the system components. The communication path is a two-pair, party line, time-serial Monitor and Control Bus. The Controller (the computer) outputs time-serial, simplex mode messages to the system devices via the Command (XMT) bus. XMT bus messages are either control messages or monitor requests. Monitor request messages return communication status information or monitor data messages to the controller. The VLBA Monitor and Control Bus (XMT and RCV) conforms to the EIA RS-485 signal specification. The XMT and RCV bus message formats and protocol are described by specification A55001N001 (section 6 in VLBA Technical Report No. 12).

The Standard Interface Board is typically a modular component of a device and functions as a serial-parallel converter to interface the Monitor and Control Bus to the devices that are to be controlled or monitored. Some devices are modules, such as a receiver control unit or an IF processor; other devices are subsystems, such as the weather station for example. In this case, the use of the Standard Interface in monitor and control interfacing is very simple; the chief differences between applications are the character and volume of control or monitor operations be performed.

Because analog signal multiplexing and A/D conversion are frequently required, the Standard Interface Board contains an optional analog multiplexer-A/D converter. The converter is integrated into the logic of the interface so that it may be easily applied to analog signal monitoring applications. Additional analog multiplexers installed in the device circuitry may extend the analog multiplexing capacity of the interface.

The Standard Interface Board is always used in conjunction with digital circuitry, in this case the A2 Logic Board, that implements the device address, command and monitor data functions.

The SIB is an address-restricted implementation of specification A55001N002-A (also section 6 in VLBA Technical Report No. 12). The board device address capability is 256 command and 256 data channels. In addition there are 16 interface internal command and 16 interface internal data addresses. The message format specifications (cited above) do not define the maximum size of an interface address block; it could be any size within the specified address range. The interface board specification is both a functional and physical specification in that it defines the functional properties, physical size, and I/O connector types and pin assignments.

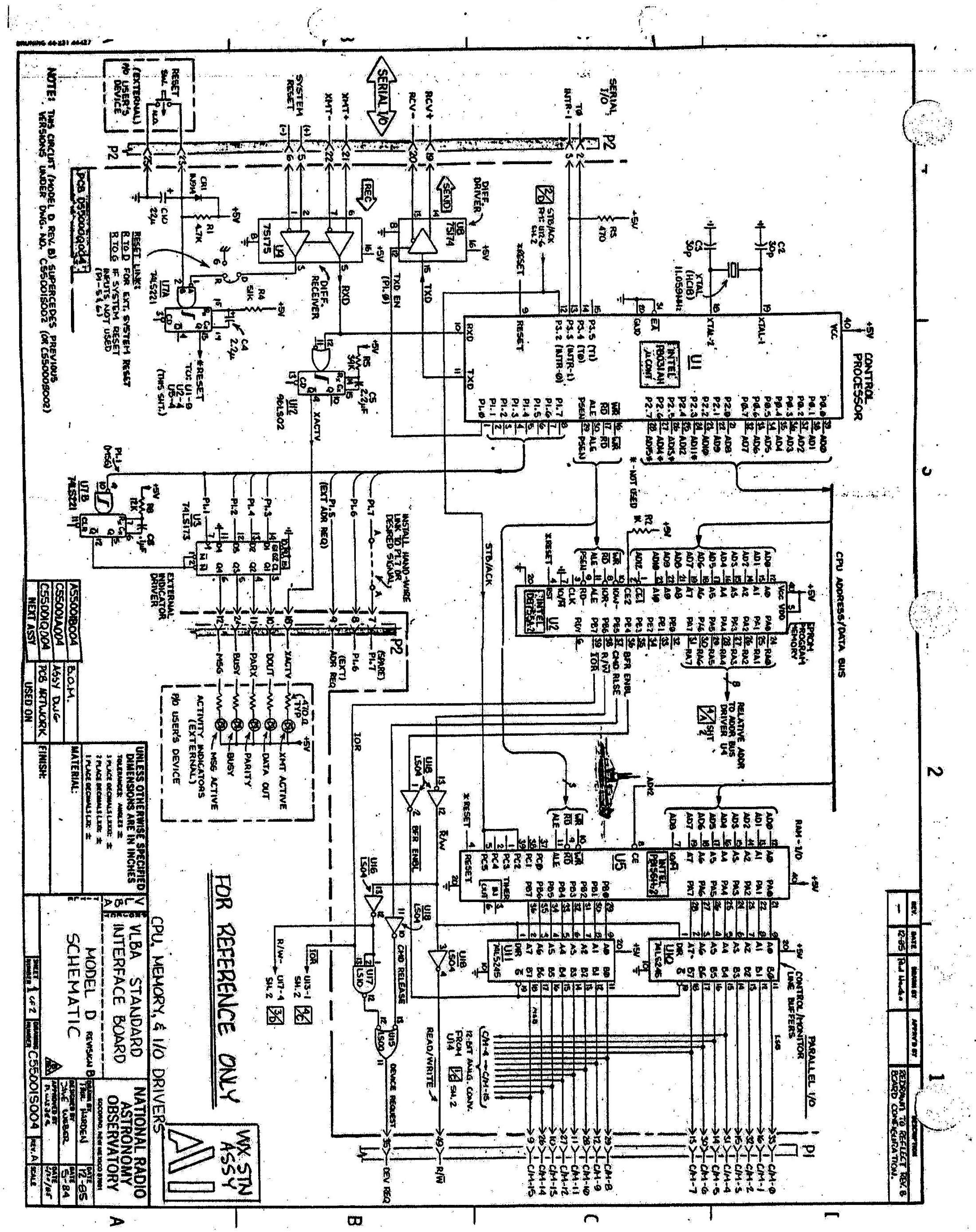


Figure 21 Standard Interface Board Model D Schematic, C55001S004-1

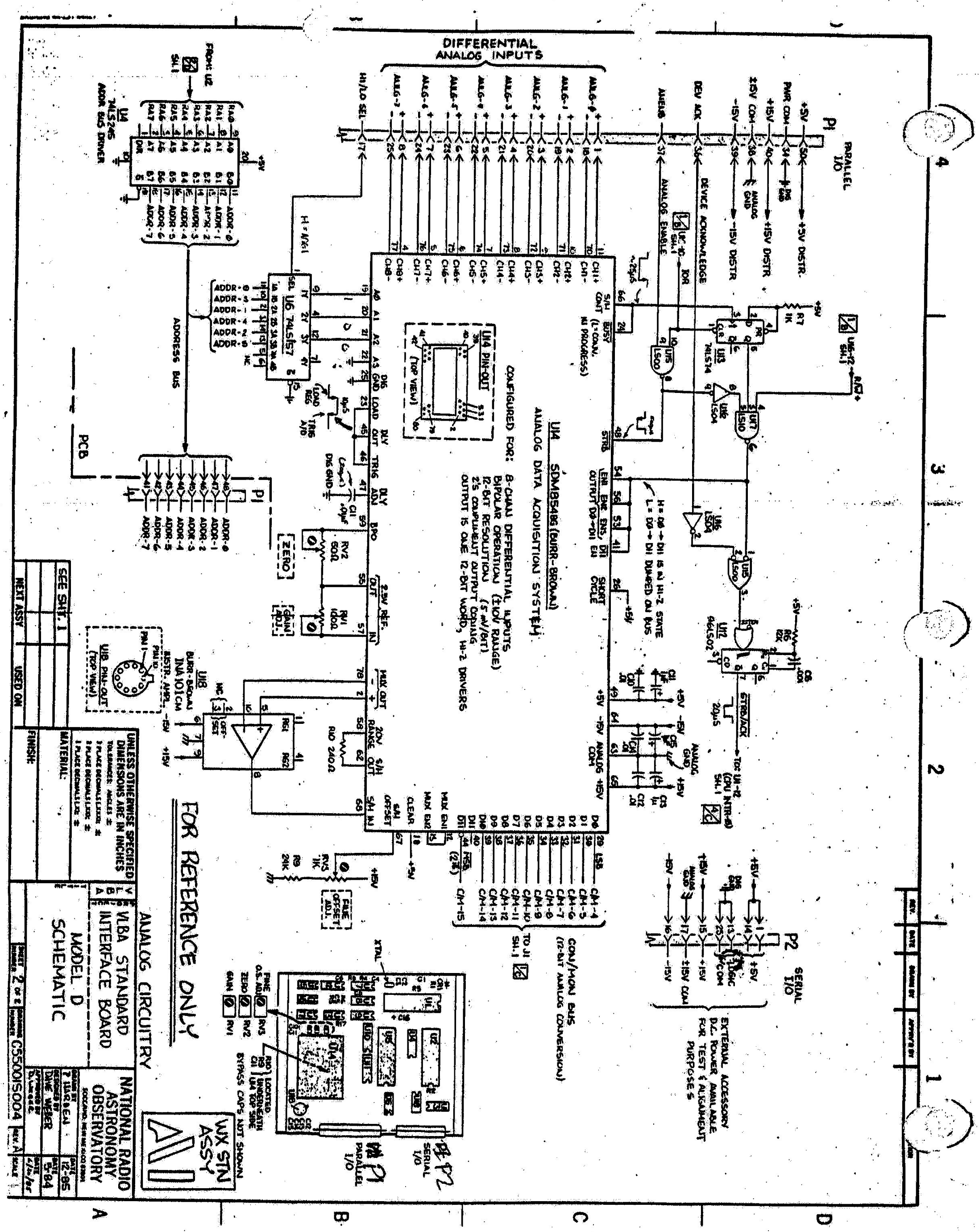


Figure 21 VLBA Standard Interface Board Model D Schematic, C55001S004-2

A2 Logic Board

The A2 Logic Board is a 6" x 7" wire-wrap board with a 100-pin edge connector. The logic board stores and distributes the digital information furnished from the sensors and their component parts to the Standard Interface Board when requested. It decodes the address, handles digital command & monitor data, and performs some analog multiplexing for the analog 1 and analog 2 lines to the A/D converter on the Standard Interface Board. The logic board also initiates control and handshake functions to receive digital information from the barometer.

Figure 22 is the VLBA Weather Station A2 Logic Board Schematic, C55006S006. Refer to this drawing for troubleshooting and analysis purposes.

There are three decode functions for the A2 Logic Board. They are the digital command decode, monitor data decode and the relative address block decode. Relative address blocks are hexadecimal in format, and are listed as such in VLBA Technical Report No. 5, List of Current Monitor and Control Points. The logic for each is a 74LS138 three-line to eight-line decoder. This logic decodes one of eight lines dependent on conditions at the three binary select inputs and the three enable inputs.

U30 decodes the relative address lines A3-A7 with device request, this decoder produces five blocks of relative address enables which are 0-7, 8-0F, 10-17, 18-1F, and 20-27. The first three blocks 0-7, 8-0F, and 10-17 are used for the analog monitors. Block 10-17 is used to enable the digital monitors via U26. Block 20-27 is used to enable digital commands via U25.

Address lines A0-A2 are the binary select inputs to the digital command decoder and monitor decoder on pins 1, 2 & 3 of U25 & U26 in order to select one of 8 functions within a block.

Pin 6 of U25 is pulled high so that pins 4 & 5 will enable U25. U25 will only be enabled if block 32-39 is active (pin 11 of U30) and R/W is set to write mode (low). The outputs from the digital command decoder are reset lines for the TSL (RA22), the peak windspeed latches (RA23) pin 1 of U23 & U24, and the rain-gauge binary counters (RA24) pins 2 & 12 of U39 & U40.

The TSL reset line goes to the A5 TSL Receiver Board, it resets the TSL min/max temperature to the current temperature. The wind speed reset activates the latch reset on pin 1 of U23 & U24, and resets the peak wind gust reading to zero. The rain-gauge reset activates the binary counter reset on pins 2 & 12 of U39 & U40, and resets the rain-gauge counters to zero.

The enable inputs to the monitor decoder is R/W at pin 6 of U26, and block 18-1F decodes from pin 12 of U30 relative address block decoder to pins 4 & 5 of U26. U26 will only be enabled if block 18-1F is active and R/W is set to the read mode (HIGH).

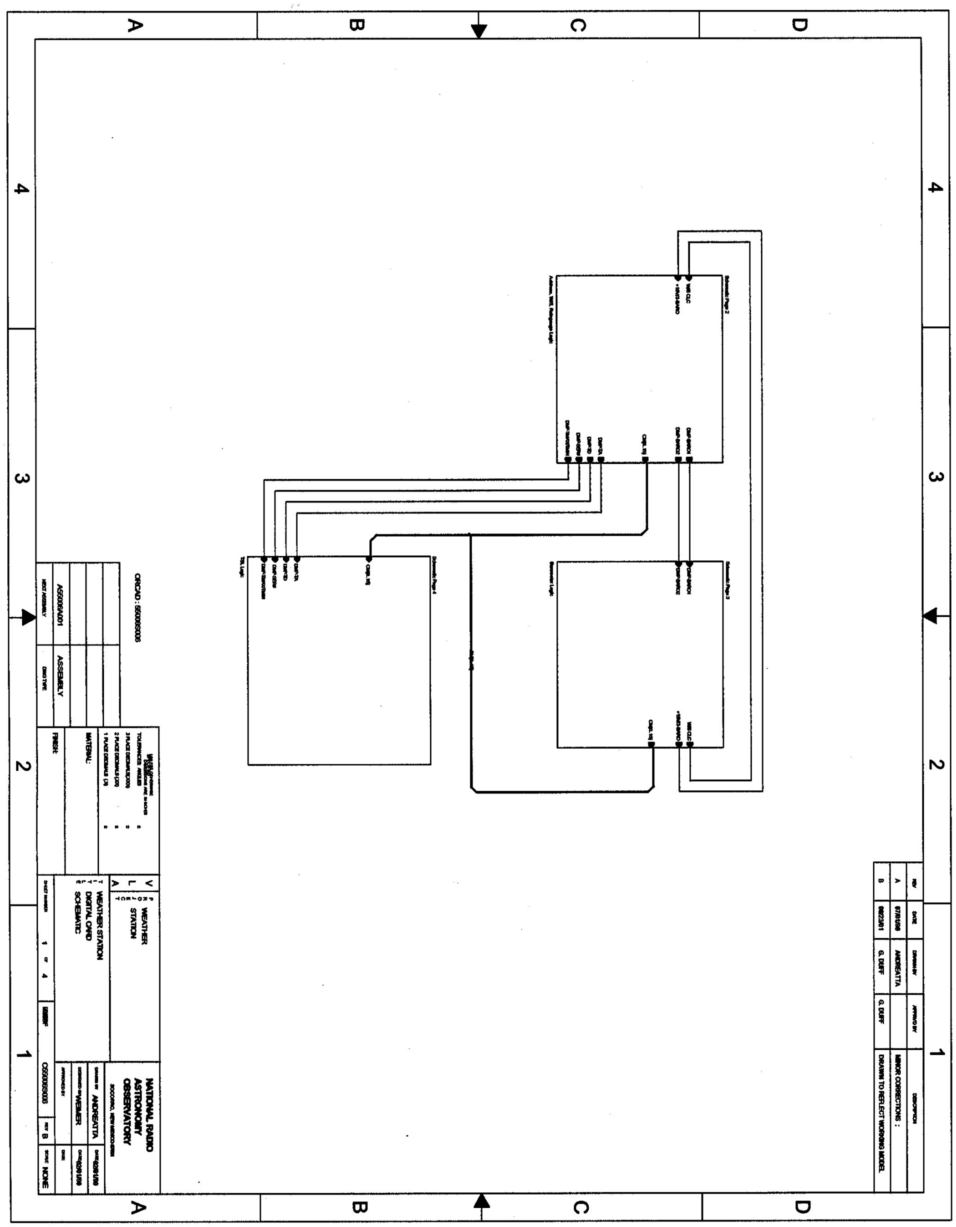


Figure 22 VLBA Weather Station A2 Logic Board Schematic, C55006S006-1

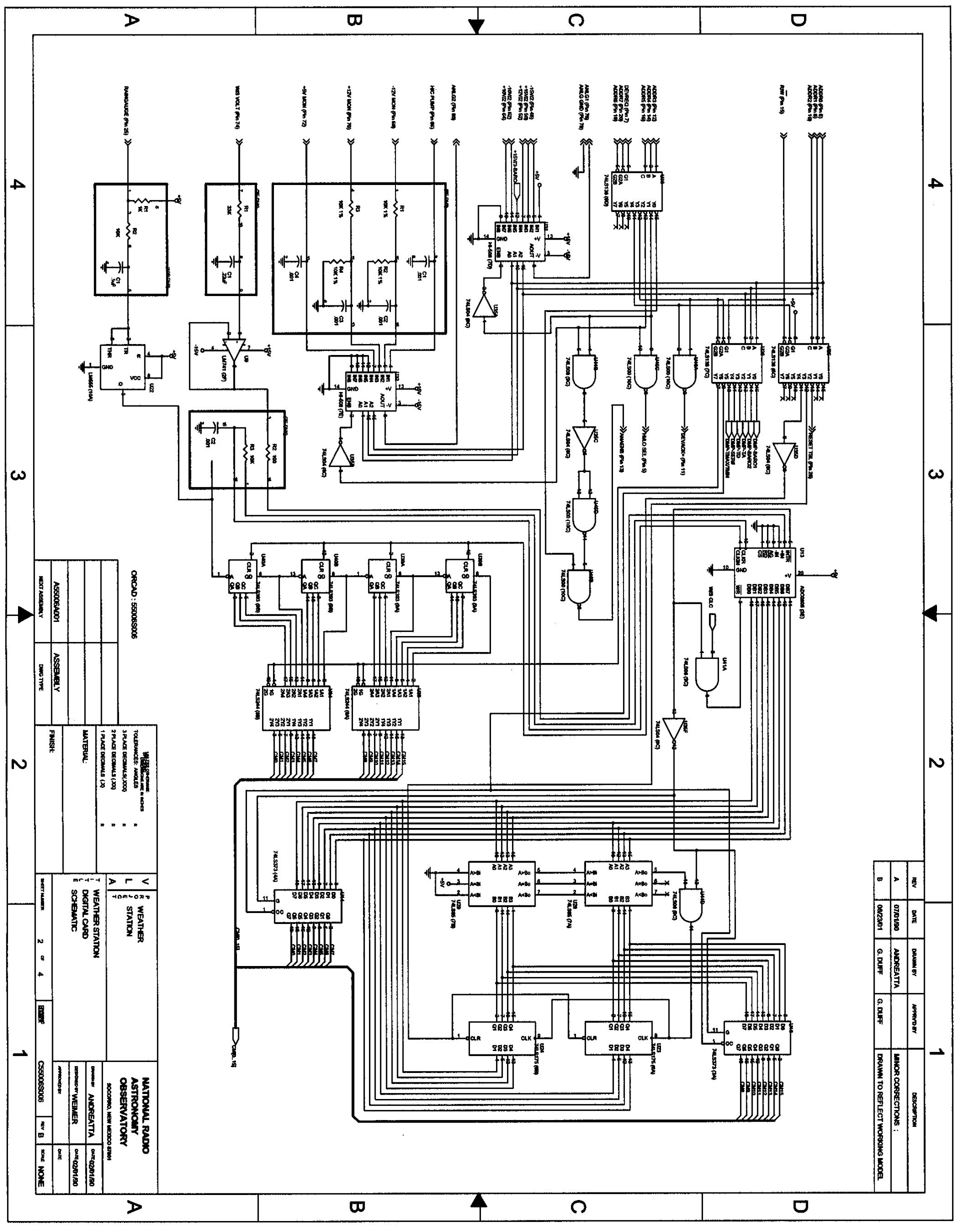


Figure 22 VLBA Weather Station A2 Logic Board Schematic, C55006S006-2

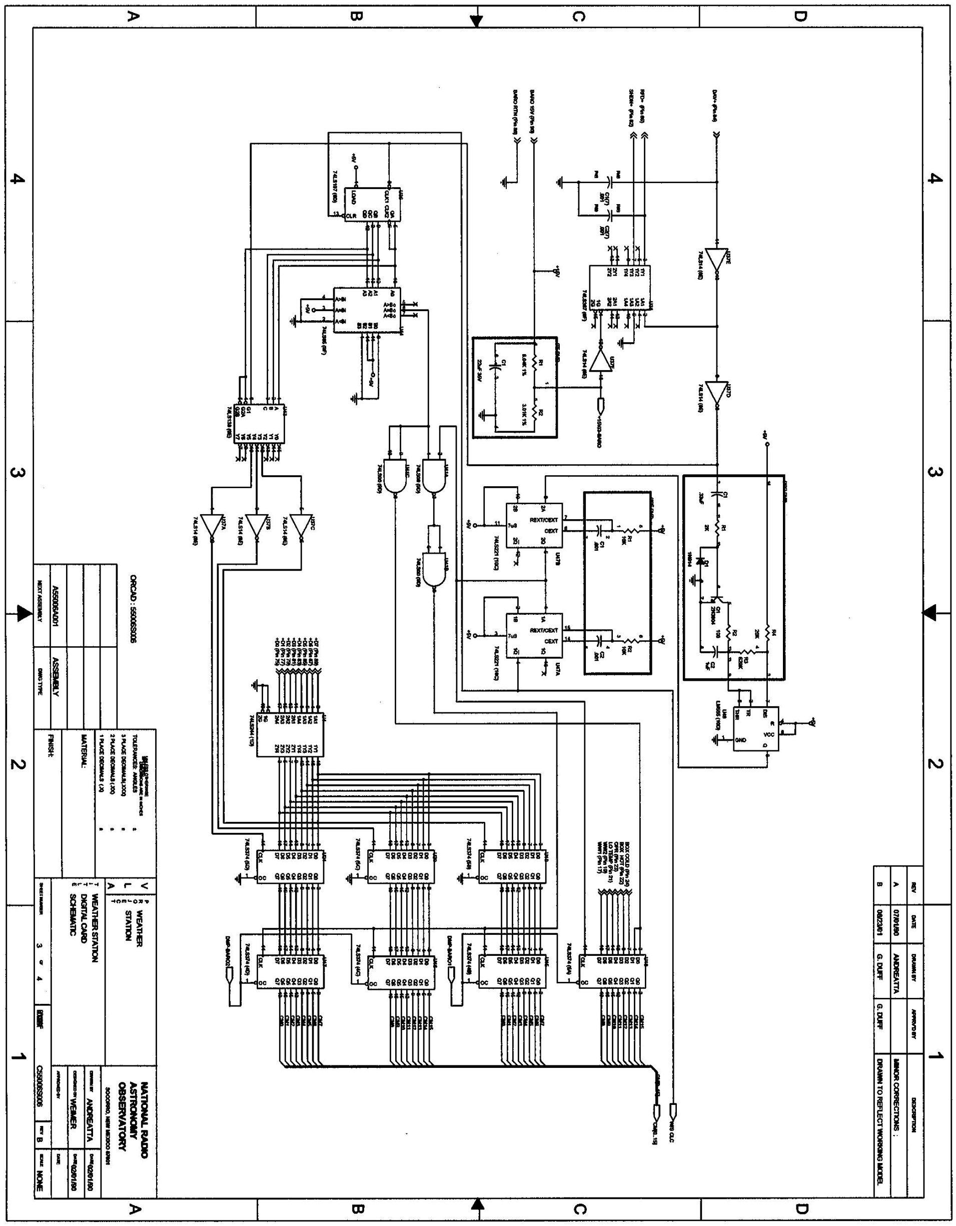


Figure 22 VLBA Weather Station A2 Logic Board Schematic, C55006S006-3

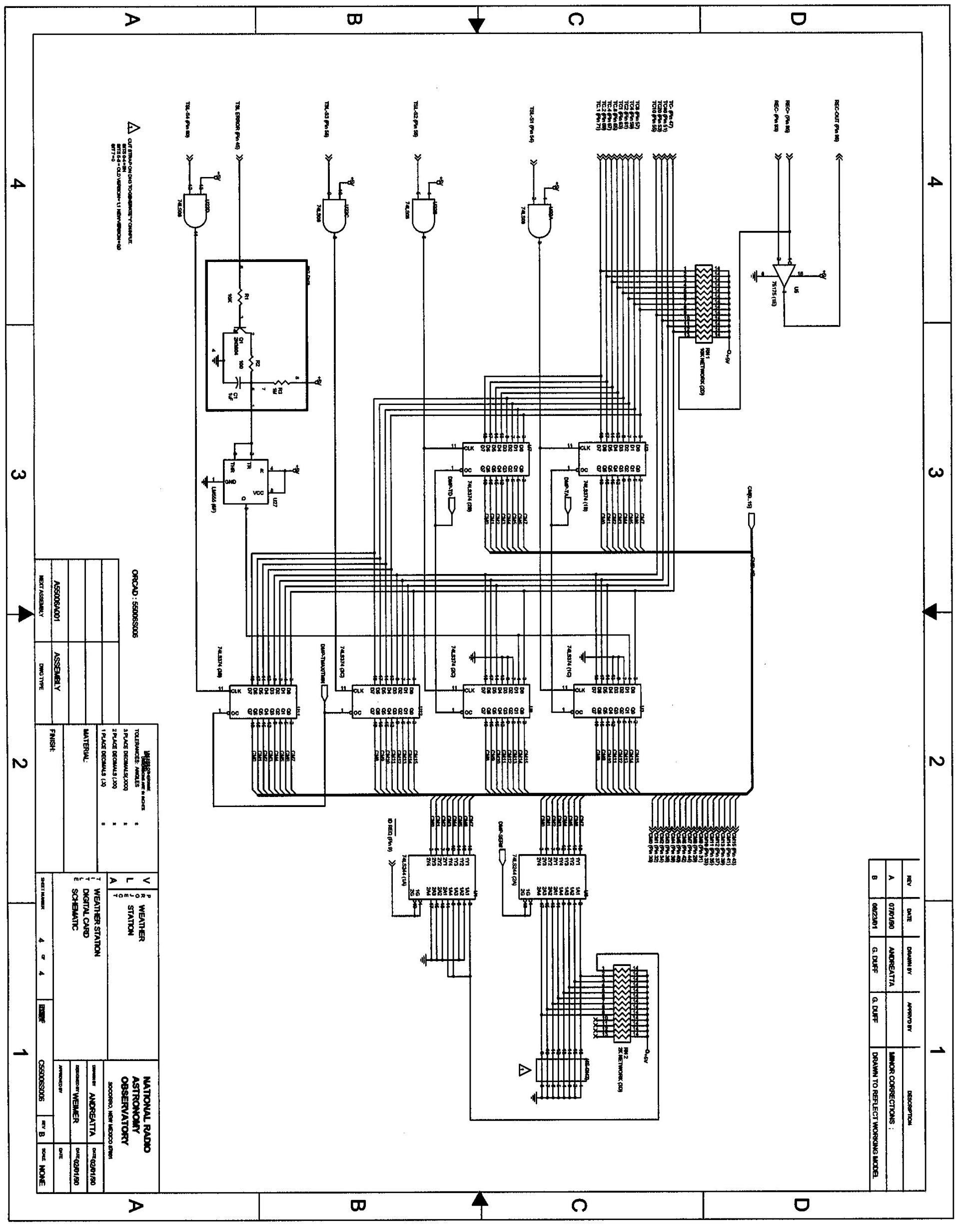


Figure 22 VLBA Weather Station A2 Logic Board Schematic, C55006S006-4

The outputs from the monitor decoder are tri-state output enable lines to the latches for the barometer (RA18) pin 1 of U16 & U17 and (RA19) pin 1 of U15 & U18. For the ambient temp/dew point (RA1A, RA1B), it is pin 1 of U2 & U3. For the minimum and maximum temperature (RA1D) pin 1 of U11 & U12, the serial number (RA1C) pins 1 & 19 of U6, the wind speed (RA1E) pin 1 of U10 & U14, and the rain-gauge (RA1F) pins 1 & 19 of U33 & U34.

The monitor data for the barometer also includes status information for box temperature hot (fan turned on), cold (heater turned on), a low temperature warning for antenna stow, excessive wind warnings, and barometer error. With the exception of the barometer error, all status information comes from the A3 Analog Board. These inputs are pins 7,8,13,14,17 & 18 on U18. Barometer errors are reported on pins 3 & 4 of U18.

The handshake and control for the barometer is a two-line function used to synchronize transfers between the barometer and the A2 logic board. The A2 logic board controls the RFD+ (ready for data) signal and the barometer controls the DAV+ (data valid) signal. The RFD+ is active high, generated from pin 3 of U38 to the barometer. Consequently, after the barometer has completed a measurement averaging cycle it tests the RFD+ signal for the active state, and upon detecting the RFD+ signal, it begins the data transfer sequence.

The barometer monitor data is input in from the barometer through U4, a 74LS244 octal buffer and clocked into 74LS374 latches U19, U20 and U21 to store the data as 3 eight-bit words.

Each +DAV trailing edge will clock pin 8 of U36 until states 3, 4 & 5 are presented to U43 while it is enabled during +DAV. States 0, 1 & 2 are disregarded, however only states 3, 4 & 5 will clock the data into U19, U20 & U21 respectively by the rising edge of +DAV.

U48 is a 555 timer running as an astable oscillator with ~70% positive duty cycle, with a frequency of ~1.14 Hz. The first +DAV pulse, consequently providing the bias voltage for Q1 on header 10G-DH8 triggers it high. This forces the threshold voltage on pin 6 of U48 below the normal 1/3Vcc condition that allows the 555 to free run at ~50% positive duty cycle. The net effect is that it takes a longer period of time to charge capacitor C2 to above the 1/3Vcc and then to the 2/3Vcc condition, thus stretching the output of U48 to around 700ms. This is adequate enough time to load the data into U19, U20 & U21, which is clocked by the +DAV pulse.

The barometer takes 10 measurements per second and averages the result, which in turn is available at D0-D7 every second. The 555 timer gives the loading process plenty of time (555 frequency ~1.14 Hz) for the data cycle to complete one measurement process.

When U36 reaches state 6, the magnitude comparator U44 recognizes this condition and outputs the high state, which in turn supplies the status bits for the barometer, in this case 0's on pins 3 & 4 of U18. This is of course when the electronics are working properly, and the barometer is dutifully reporting atmospheric pressure.

When the output of the 555 timer is high, likewise the input pin 9 of U47B is high as well. The negative going transition from high to low on pin 9 of U47B as qualified from the 555 timer duty cycle supplies the high clock pulse to parallel load the data into U15, U16 & U17. This also forces pin 4 of U47A to output a low, which in turn clears the state machine U36, and be ready to start again with the next measurement.

If for any reason +DAV is unavailable or any other malfunction in the circuitry, the state machine U36 and its cohort U44 will be unable to identify the subsequent state 6. The result is a low condition on pin 6 of U44, which sets the status bits to 1's on pins 3 & 4 of U18. This is identified as an error condition in the software program, thus the data will be disregarded.

Likewise, if there is no positive going transition from pin 5 of U47B, there can be no new data parallel loaded into U15, U16 & U17. Visually on the overlay screen this would appear as an unchanging barometric pressure reading.

The SHDN+ (shutdown) feature for the barometer is not used in this application, however the input is grounded through pins 6 & 7 of U38 to prevent any capacitively coupled signals from activating the SHDN+ pin on the barometer.

The monitor data for the ambient and dew point temperatures are input from the A5 TSL Receiver Board, and is three binary coded decimal (BCD) values. The input signals are pulled-up via a 10KΩ-resistor network RN1. The logic board uses bits TC 0.1 through TC 40 on bits 0-10 of the storage registers for the BCD values, with TC – on bit 15 to indicate the sign of the value (±). Bits 11-13 are unused, and bit 14 indicates an error. Bits 0-7 measure tenths and ones, but bits 8-10 measure tens. It's important to remember that the values are BCD in format.

74LS374 registers U2 & U3 are loaded with the ambient temperature, while U7 & U8 are loaded with the dew-point temperature. There are two clocks generated at the A5 TSL Receiver Board, TSL S1 for the ambient temperature and TSL S2 for the dew point temperature. The ambient temperature gets clocked on pins 11 of U2 & U3. The dew point temperature is clocked on pins 11 of U7 & U8. The current latched values are transferred to the SIB when requested.

The technique is repeated for the minimum and maximum ambient temperatures, however only the sign, the tens, and ones are loaded into the registers. The tenths values are ignored. The storage registers for the minimum and maximum temperatures are U11 & U12 respectively. There are two clocks from the A5 TSL Receiver Board, TSL S4 for minimum temperature and TSL S3 for maximum temperature. Minimum temperature is clocked on pin 11 of U11, and maximum temperature is clocked on pin 11 of U12. The current latched values are transferred to the SIB when requested.

The serial number identifying the location of the weather station is generated on the logic board. DH2-4E is an eight-pin header wired to reflect the serial number of the station. A cut link on DH2-4E indicates a high value, while a closed link is a low value. The inputs are pulled up via a 10kΩ-resistor network. The ID (weather station in hex = 18) is hard-wired on board. This information is passed through 74LS244 buffer/drivers U1 and U6 to the SIB when requested for ID and serial number respectively.

The monitor data for the wind speed/wind gust is routed through a buffer U2F, a 741 Op-amp non-inverting buffer to the ADC0805 Vin+ on pin 6 of U13. The analog-digital converter has eight bits of resolution with an on-chip clock generator. The outputs of the ADC are used for current values for wind speed, and for peak wind gust values. Bits 0-7 are used for the current wind speed and bits 8-15 are used for the peak wind gust. Four-bit magnitude comparators 74LS85 U28 & U29 compare the current peak wind gust values with the previous latched values in 74LS175 U23 & U24 to determine which one is the highest value, thereby providing a current peak wind gust value to 74LS373 latch U10. The information is transferred to the SIB when requested.

The rainfall gauge monitor data is derived from a switch closure in the rainfall gauge and a high-low signal is thus generated through a voltage divider RC network on the logic board to provide stable trigger mechanism for the clock element for the binary counter. A 555 timer U22 provides a positive de-bounced clock when the contact closure in the rainfall gauge is made, initiating a binary count for the cascaded counters 74LS393 U39 & U40. The current counter values are passed through 74LS244 U33 & U34 to the SIB when requested. Each count is equal to 0.1mm precipitation measured over the collection surface area.

The output lines from the relative address block decoder Y0-Y2 pins 13,14 & 15 of U30 are used for ANAENB for the SIB, which specifies the analog monitor data to be sampled. In this case, relative addresses RA00-RA17. These monitor points include all analog portions of the weather station. Y1-Y2 pins 13 & 14 of U6D are used for HI/LO SEL for the SIB and for this application both the on-board and device multiplexers are used. This allows for the relative addresses to be RA08-RA17, which in fact are the monitor data inputs to the logic board analog multiplexers HI-508 U31 & U32. Y3-Y4 pins 11 & 12 of U30 are used for the DEVACK+ for the SIB, which signals that the device has accepted command data or has written monitor data on the data bus. This includes commands and monitor data for relative addresses RA18-RA27.

The analog multiplexing on the logic board sends analog signals for ANLG1 and ANLG2 U31 & U32 going to the SIB. There are two eight-channel multiplexers on the logic board, each a HI-508. The decode address lines are A0-A2, pins 1,15 & 16 on U31 & U32.

Analog multiplexer U31 is associated with ANLG1 to the SIB. This multiplexer selects voltage monitor points coming from the A3 Analog Board. The voltage monitor points are –15V/2, +15V/2, +12V/2, +15V/3, -10V/2, +10V/2, +5V, and GND. The pins corresponding to the inputs are pins 5,6,7,12,11,10,4, & 9 on U31. The enable input to this multiplexer is from Y1 pin 14 of U30 on the relative address block decoder. The enable input on the multiplexer is pin 2 of U31.

Analog multiplexer U32 is associated with ANLG2 to the SIB. This multiplexer selects voltage monitor points coming from the TSL transmit card. The voltage monitor points are the heat/cool pump for the chilled mirror, -12V, +12V, +5V, and GND. They monitor power and the control voltages heating and cooling the chilled mirror in the dew point sensor assembly. The pins corresponding to the inputs are pins 4,5,6,7,9,10,11 & 12 on U32. The enable input to this multiplexer is from Y2 pin 13 of U30 on the relative address block decoder. The enable input on the multiplexer is pin 2 of U32.

A3 Analog Board

The A3 Analog Board provides for signal conditioning from the sensors in preparation for the analog to digital conversion process on the Standard Interface Board. Voltage references is used on this board for indications setting the alarm trip conditions for low temperatures and two high wind-speeds to the antenna control unit (ACU). There is also voltage reference to detect electronic enclosure hot or cold conditions, which provides for either turning on the box fan or heater depending on which condition is present.

Figure 23 is the VLBA Weather Station A3 Conditioner Board Schematic, D55006S005. Refer to this drawing for troubleshooting and analysis purposes.

The fiber optic transmit and receive devices are included on this board assembly, however the digital transmit and receive signals are routed directly to the Standard Interface Board. Fiber optics is to provide for isolation between the weather station and control building to prevent damage from occurring due to lightning either at the tower or the control building.

There is also a small relay board sub-assembly mounted on the A3 Analog Board. This board is to provide some isolation between the weather station and the ACU located in the pedestal room of the antenna. The alarm trip levels should de-activate the small relays and remove the illumination of the LEDs on the circuit board as a convenient means of adjustment and testing during preventive maintenance procedures.

The fiber optics is mounted on small sub-assembly boards and includes TTL driver or receiver devices. The transmit line is routed from the Standard Interface Board to a Hewlett-Packard HFBR-1404 fiber optic transmitter via a 75451 driver. The 75451 driver is used for adequate TTL levels from the SIB to the transmitter.

The receive line is routed to the SIB from a Hewlett-Packard HFBR-2402 fiber optic receiver via a 75452 receiver chip. The 75452 receiver is used for beefing up the TTL receive levels from the receiver to the SIB.

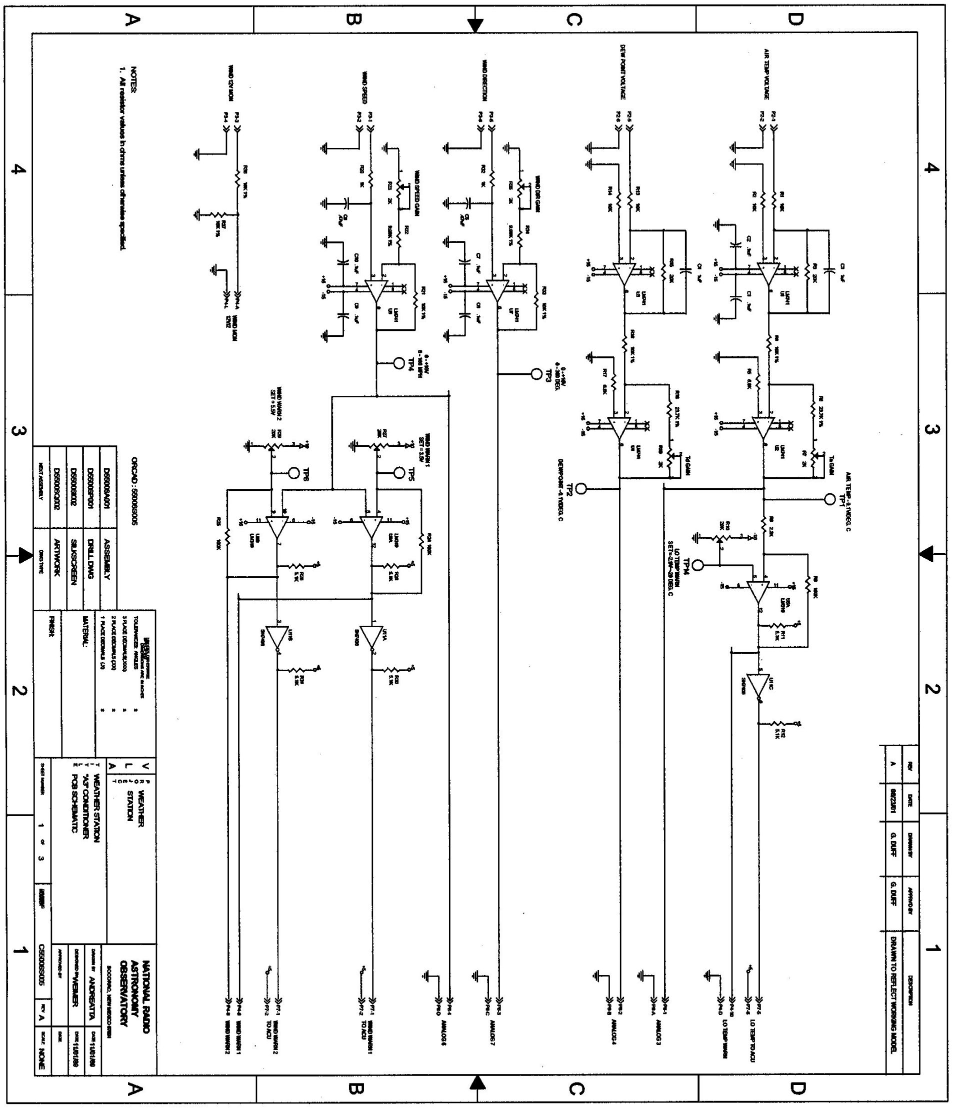


Figure 23 VLBA Weather Station A3 Conditioner Board Schematic, D55006S005-1

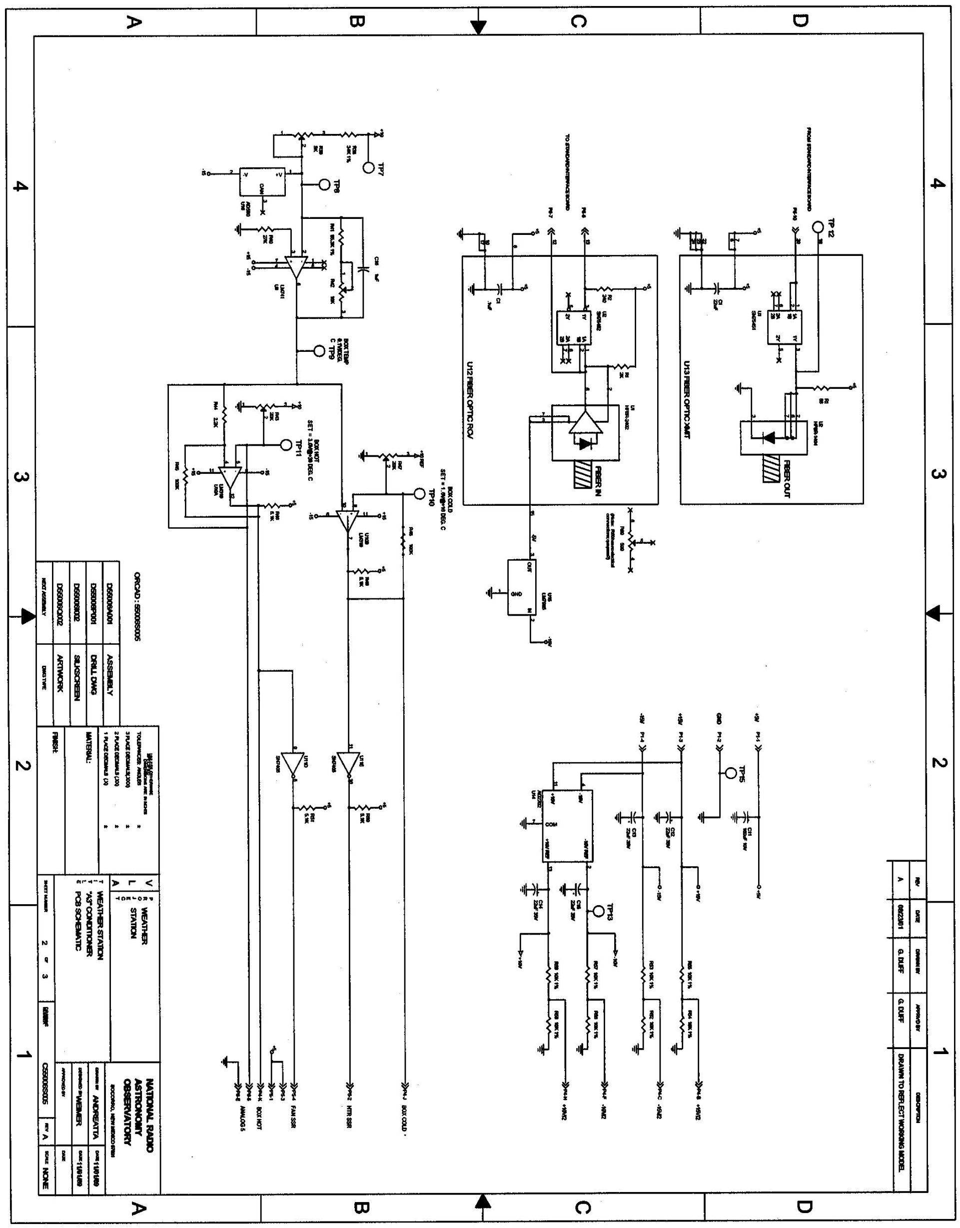


Figure 23 VLBA Weather Station A3 Conditioner Board Schematic, D55006005-2

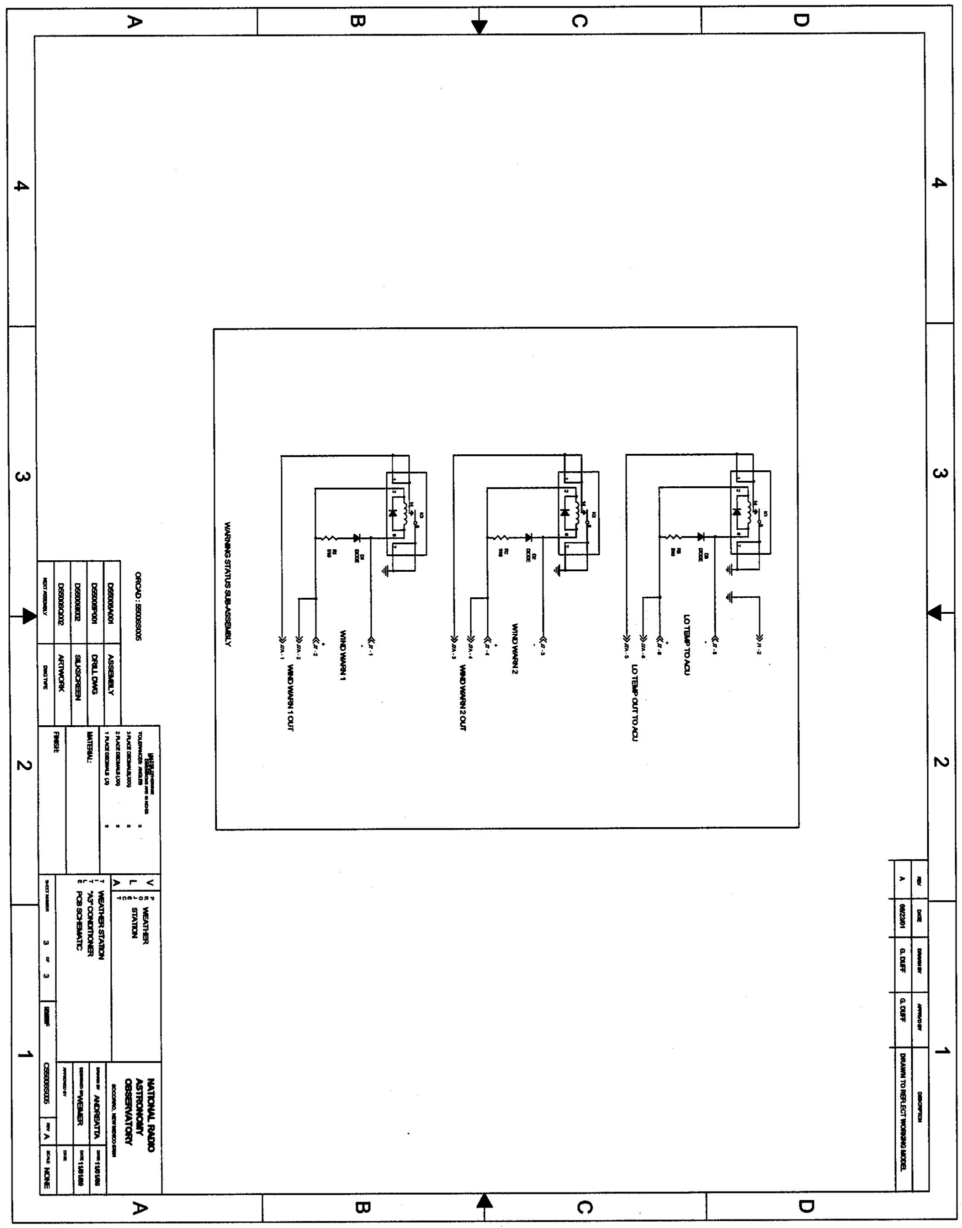


Figure 23 VLBA Weather Station A3 Conditioner Board Schematic, D55006S005-3

The relay sub-assembly provides a switch opening to the ACU when the set trip levels are activated. The outputs of the respective alarm circuits de-energize the coil, which in turn opens the continuity path to the ACU. This is the stimulus to initiate the antenna stow conditions in the ACU.

This sub-assembly is equipped with LEDs to indicate when the trip levels have been exceeded and the relay contacts have been opened. This is useful when the preventive maintenance schedule requires board alignment procedures.

The input lines for the alarm circuitry for the analog board typically is routed into op-amp circuitry that 1) provide a good signal to noise ratio, 2) amplification, and 3) trip level thresholds for the alarm conditions.

When the signals first are received on the board, only the rise in signal is desirable. Unwanted, noise or transient induced variations could produce a false alarm if a good common-mode rejection circuit was not in use in the first stage. After this stage, an amplified signal is desirable for use as an input to the comparator stage. The amplifier is nice for good isolation as well, it has a high input impedance with a low output impedance. Finally, a comparator with adjustable trip points referenced from a convenient, precision voltage source to produce the on/off conditions necessary for stowing the antenna.

The box cold/hot is similar, with the addition for a current source from the AD590. This device is a temperature-sensing device that produces changes in output current proportional to variation in temperature. This output must be converted into a voltage output, which in turn then produces the on/off condition for either heating or cooling the electronics enclosure.

The remaining circuitry on the analog board is passive, and provides for voltage monitoring points.

A4 Wind Signal Processing

This section is excerpted directly from the Qualimetrics manual in Appendix 2 of this manual. There are three modules associated with the wind signal processing for our application in the weather station. One is a power supply module, and the other two are signal-conditioning modules. These are housed in a Qualimetrics Model 1023 Module File. A series of printed circuit board edge connectors are located inside the card file to bus all common signals and power supply voltages from the power supply module to all other modules. A power cord on the back panel provides 115/230 VAC, 50/60 Hz to the power supply module.

Refer to Appendix 2 for drawings and schematics for the A4 signal conditioning electronics.

First, quick overviews of the module file. With exception of the power supply, all modules have two connectors. The top connector provides input/output connection to sensors and data acquisition equipment. The bottom connector provides common busing of power and control lines from each module to the power supply. The power supply connector, besides providing the above lines, also connects the power source with the circuit board. Refer to Figure x for a schematic of the module file. The safety ground wire of the AC power cord is tied to chassis ground. The system common is a floating signal and should not be tied to chassis ground. A chassis ground screw terminal is located below each terminal block to be used to ground shielded cables.

A Qualimetrics Model 1030-A Power Supply Module is designed to provide power for the signal conditioning modules. It provides ±12 VDC regulated power to the power bus in the module file.

The power supply requires either 115 or 220 VAC. Conversion from one to the other is accomplished by changing jumper wires on the printed circuit board. It is used with systems that do not require RF suppression filters.

AC power is input on the printed circuit connector pins 1 & 3. The neutral side of the line voltage ties directly to the primary winding of the transformer. The hot side is connected to fuse F1 on the front panel. Fuse F1 is connected to the power switch and then terminates at transformer T1. Jumpers W1 & W2 are installed for 115 VAC. VLBA antenna sites utilize the 115 VAC as the AC power source.

The secondary windings of T1 are rated at 12 VAC @ 500 mA. These feed a full-wave bridge rectifier CR5. The DC voltage obtained at the full-wave bridge is filtered by capacitors C8 & C4 and is applied to input terminals of ICU1 and ICU2. These IC's are three-lead voltage regulators rated at 12 VDC.

Capacitors C1 & C2 are used to improve transient response of the circuit. Diodes CR2, CR4, CR1 and CR3 are used to keep reverse currents from entering opposite power sources. Varistors V1 & V2 are transient protectors for the power supply bus. The green front panel indicator, DS1, connected across the negative power supply, illuminates when AC power is applied.

The black test point on all modules is system common. The brown test point is –12 VDC supply while the red test point is +12 VDC supply.

The ±12 VDC bus leaves the power supply card on pins 12-14 and is bused to all other modules through printed circuit connectors.

The wind speed module is a Qualimetrics Model 1220. The wind speed module provides a linear DC signal output proportional to wind speed over the 100-mph range. The module has a reference voltage for sensor excitation and/or scaling reference supply. An LED indicator is mounted on the front panel and it will illuminate when the module is in either LOW or HIGH calibration. A rotary switch selects either the OPERATE, LOW calibration, or HIGH calibration mode of operation, however calibration for these modules is performed at the DCS lab in Socorro, NM.

The input to the wind speed module is a pulsed square wave, and is generated by the wind speed anemometer. The input signal at pin 8 enters the switching network, S301 and jumper JW301. From there, it enters the non-inverting input of IC301. This op-amp performs several important tasks. First, through resistor R308 it references the output level to a slightly positive value (+2.5 VDC). Since the positive supply is 5 VDC and the gain of the amplifier is ~ 4.5, the output signal is clipped at approximately 5 VDC.

The output of IC301 goes through current limiting resistor, R310, and the low state is held at ~ system common level by the input diode clamp of IC302. R311 is a pull-up resistor for unused inputs of IC302, a Schmidt trigger. The Schmidt trigger defines the on and off times more precisely for triggering the one-shot, IC303.

Capacitor C302, diode CR303 and resistors R312 & R313 make up a differentiator circuit to trigger the one-shot on the falling edge. R312 & R313 set the low state level while CR303 sets the high state level.

IC303 is a timer used as a one-shot with resistor R315 and capacitor C304 as its timing elements. The time constant for the circuit is found from the formula:

$$T \approx 1.1\ RC$$
$$\approx 1.1\ (75K)\ (.01\mu F)$$
$$\approx 825\ \mu S$$

An 825 µS pulse width signal is generated by IC303 with voltage amplitude of 5.0 VDC. Resistor R314 loads the circuit enough to insure stability over the entire frequency range.

IC304 integrates the area under each pulse entering its input and provides a proportional DC output level. Resistors R318 & R319 are used as a gain doubling circuit for wind speed range select.

IC304 signal output is inverted by IC305. The gain of this circuit is set so that the value at the violet test point varies approximately 0 to –5.5 VDC.

The input to IC201 is derived from IC305 pin 6 and can be measured at the violet test point. This voltage is summed with the zero adjust voltage and enters IC201 pin 2, the inverting input. CR201 & CR202 regulate the voltage across potentiometer VR202 to stabilize its value. Potentiometer VR202 is used to zero both outputs. IC201 has a variable gain due to potentiometer VR201 that is used to obtain the full-scale value at output 1. After output 1 is set, potentiometer VR203 is adjusted for full-scale reading of output 2.

Voltage regulator, IC101, obtains its power from the +12 VDC bus referenced to common. IC101 is a three-lead positive voltage regulator fixed at 5 VDC.

To calibrate the circuit, a free running oscillator is designed for the HI calibration position of the mode switch. Capacitor C301 and resistors R304 & R305 determine this frequency which is ~ 470 Hz.

The wind direction module is a Qualimetrics Model 1240-A. It has a reference voltage for sensor excitation and/or scaling reference supply. An indicator is mounted on the front panel and will illuminate when the module is in either LOW or HIGH calibration or HIGH calibration mode of operation. Front panel controls are available for adjusting the low and high span points for both outputs.

The signal from the wind vane is fed through two stages of amplification before entering the output stage. A small filter capacitor on the input line removes external noise. The wind direction module provides linear signal output over the 360° range.

The sensor is connected to the module with a three-conductor cable. The white conductor terminates sensor pin A to wind direction module pin 2, and supplies the excitation voltage to the potentiometer. R302 is used for short circuit protection. The black lead connects pin B of the sensor to pin 4 of the module and represents system common. The red lead is the potentiometer wiper output and connects pin C of the sensor to pin 6 of the module.

The signal passes through the mode switch and jumper JW301 and enters pin 3 of U301. The mode switch substitutes the zero and full scales values of the sensor in the LOW and HIGH calibration positions, respectively. Buffer amplifier, U301, provides an impedance match between sensor and electronics. This amplifier has unity gain.

The output of U301 enters the inverting input of U302. This second amplifier has a gain of approximately –2. This gain is selected to provide a 0 to –5.5 VDC signal to U201 pin 2 and this voltage can be measured at the violet test point. The input voltage at U201 pin 2 is summed with the zero-adjust voltage and is applied to the inverting amplifier input. CR201 & CR202 regulate the voltage across potentiometer R202 to stabilize its value. Potentiometer R202 is used to zero both outputs. U201 has a variable gain due to potentiometer R201 that is used to obtain the full-scale at output 1. After signal output 1 is set, potentiometer R203 is adjusted for full-scale reading of signal output 2.

Voltage regulator, U101, obtains its power from the +12 VDC bus and is referenced to common. U101 is a three-lead positive regulator fixed at 5 VDC.

Relay K301 is a printed circuit board assembly with two each DPDT relays in it. The K301A section is used to remotely switch from the sensor to the LOW calibration position. The K301B section along with the K301A section is used to switch from the LOW to HIGH calibration position.

A5 TSL Receiver Board

A substantial portion of the receiver board has been discussed above in the TSL Model 1063 Hygrothermometer theory of operation. This section is additional information regarding the receive board function in the weather station.

Figure 20 is the VLBA Weather Station Receiver PCB Logic Diagram, C55006L002. Refer to this schematic for troubleshooting and analysis purposes.

The receiver board performs the data display function for the TSL. It receives the transmitted serial binary multiplexed ambient temperature (Ta) and dew point temperature (Td) data streams and converts the data into format suitable to be sent to the A2 Logic Board. The data can then be sent via the Standard Interface Board to the central computer as monitor data when requested.

Arithmetic manipulations are performed on the data, including 5-minute averaging of Ta and Td, and recording maximum and minimum Ta. Data quality checks are performed, and the four data outputs, Ta, Td, Tmax, and Tmin can be utilized as monitor data for the weather station.

The data processor on the receiver board is a type 68701 single-chip microprocessor. It performs virtually all of the timing and logical functions of the receiver. Data is brought through a line receiver amplifier to the serial input port of the processor. Under control of the resident program, the processor gathers, computes, and stores the pertinent data. Output from the processor is on a 13-bit parallel bus that is time-multiplexed to Ta, Td, Tmax, and Tmin. As each of the data words is on the bus, a unique strobe pulse is generated, one for each of the four outputs.

When the error flag bit is received from the transmitter, or when certain other error conditions are detected by the receive logic, the error output level goes high. This indicates an unusual condition with the TSL.

The Tmax and Tmin values can be reset to the present values by sending a command via the monitor and control bus from the central computer.

In the event of a momentary or prolonged power failure, the critical part of the data processor memory remains active, powered by a small battery located on the receive board. This battery is trickle-charged during normal operation, and has enough capacity to protect to memory for approximately 10 hours. Memory protection retains Tmax, Tmin, and the averaged values of Ta and Td.

A6 A.I.R. Digital Barometer

The Barometer is an Atmospheric Instrumentation Research (A.I.R.) Model AIR-DB-2AX. It is a microprocessor controlled digital pressure transducer, and measures the atmospheric pressure in millibars. The range of this instrument is from 800 to 1060 mb. Accuracy is ±0.5 mb.

Refer to Appendix 3 for drawings and schematics for the barometer.

It measures pressure 10 times per second, averages the measurement, and makes it available in digital format. It is housed in a sealed aluminum case, uses a stable capacitance type pressure sensor, and has microcomputer control. The analog electronics and sensor are computer calibrated together for full range accuracy. The calibration data is stored in ROM memory.

The data is transferred from the barometer to the A2 logic board on a parallel 8-line input. The data is binary coded format and is transferred 8 bits at a time. A two-line handshake is used to synchronize transfers between the barometer and the A2 logic board. The A2 logic board controls the RFD+ (ready for data) signal and the barometer controls the DAV+ (data valid) signal.

On board the barometer, the logic sequence goes something like this: 1) wait for RFD+ to become asserted, 2) write data byte, 3) assert DAV+, 4) wait for RFD+ to become negated, and 5) negate DAV+. Likewise, a complementary logic sequence on the A2 logic board is reflected as: 1) assert RFD+, 2) wait for DAV+ to become asserted, 3) read data byte, 4) negate RFD+, and 5) wait for DAV+ to become negated.

When the barometer completes a measurement averaging cycle it tests the RFD+ signal. If RFD+ is negated, it starts another measurement cycle and the data is lost. If RFD+ is asserted it starts a data transfer sequence. Once a transfer is begun it must be completed before the barometer begins another measurement. If there is an interruption in the handshaking, the barometer will stop.

A7 Signal Protection Board

The surge protection is provided by gas tube arrestors which are self quenching and feature extremely fast response to transients, and the ability to withstand high follow currents.

Refer to Appendix 2 for drawings and schematics for the A7 board.

Each gas tube arrestor has two metal electrodes forming a discharge gap characterized as an open circuit under normal conditions. The arrestor represents only a very small capacitance and no resistance to the circuit it protects.

When a surge occurs and exceeds the breakdown voltage of the arrestor, the internal gap becomes highly ionized, conducting currents within fractions of a microsecond. The arrestor is then virtually a short circuit until the voltage returns to normal. Ionization and de-ionization happen extremely fast due to the type of gas in the tube and the physical configuration employed in the design.

The resistor and inductor are used in conjunction with the spark-gap tube and the dual zener diodes act to slow and quench surge currents that occur below the ionization threshold of the spark-gap tube.

A8 Box Heater

The box heater is a Hoffman D-AH1001A, a 100-watt electric heater. This heater has an adjustable thermostat with a range from 0°F to 100°F (-18°C to 38°C). The fan in the unit draws the cool air from the bottom of the enclosure and passes this air across the thermostat and heating elements before being released into the electronics enclosure.

There are no schematics for the box heater.

A9 Data Display Units

There are four temperature values that can be displayed inside the electronics enclosure. Rotating the switch on the A9 display unit box changes the display value. The values are the average ambient temperature (Ta), the average dew-point temperature (Td), the maximum ambient temperature (Tmax), and the minimum ambient temperature (Tmin). The max and min temperatures are from a 24-hour interval. The temperatures are displayed in degrees Celsius.

Refer to Appendix 1 for drawings and schematics for the A9 display unit.

The temperatures are decimal numbers, however for this data to be displayed, 11-bit binary numbers from the TSL receive card have to be converted to a BCD format. This is done by a subroutine in the MPU program on the TSL receive card. All of the output data is brought out of the MPU on 14 lines, coded as tenths, units, tens, and hundreds of degrees and a polarity bit. The data is then multiplexed to read out Ta, Td, Tmax and Tmin.

The data lines are distributed to the panel display, along with a strobe input. This allows for the display to sample the data lines when the data is valid and selected by the switch for the display.

The individual display module contains storage latches to sample and hold the data as it is strobed in. The latch modules, MC14511 contain seven-segment decoder-drivers that directly drive the incandescent segments of the decimal displays.

There is also a toggle switch for selecting the instantaneous or average values for the temperatures. Normal operation for the weather station is in the average position. If the switch is left in the instantaneous position, the error flag is set and VLBA operations will assume there is a problem with the TSL.

There is a control for the illumination of the incandescent display. Rotating the knob will increase or decrease the display brightness.

PS1 Power Supply

The power supply is regulated providing +5V, and ±15V outputs. The DC input voltage has a range of 85-132 volts AC @ 47-440 Hz. This power supply is rated at 62% minimum efficiency. There is overload protection, an automatic electronic current limiting circuit with automatic recovery limits short circuit output current to a safe preset value, thus protecting load and power supply when direct shorts occur. Sustained short circuit operation for more than 30 seconds may cause power supply damage. Internal failure is fuse protected.

The input fuse is a 2A slo-blo in the AC input line to protect the input wiring to the power supply. Overload of power supply does not cause the fuse to fail. This supply is convection cooled, so no external fans are required, and is supposed to provide continuous output voltage from 0°C to +60°C.

Appendix 5 has minimal illustrations for this power supply.