OPERATIONS MANUAL
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MODEL 210C SERIES
SIGNAL MONITOR

THIS MANUAL CONTAINS TECHNICAL INFORMATION FOR THE FOLLOWING SERIES OF MODEL 210C CONFLICT/VOLTAGE SIGNAL MONITORS: **210C**; Issue D thru G. INCLUDED ARE GENERAL DESCRIPTION, OPERATIONAL DESCRIPTION, INSTALLATION AND SPECIFICATIONS.

THE MODEL 210C SERIES SIGNAL MONITORS ARE DESIGNED AND MANUFACTURED IN THE U.S.A. BY EBERLE DESIGN INC., PHOENIX, ARIZONA.

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EBERLE DESIGN INC. (602) 968-6407
3819 E. LaSalle St. Phoenix, AZ 85040

MAINTENANCE NOTE

EBERLE DESIGN INC. SIGNAL MONITORS HAVE BEEN CAREFULLY INSPECTED AND TESTED TO ENSURE PROPER OPERATION. IT IS RECOMMENDED THAT THE SIGNAL MONITOR BE TESTED AT LEAST ANNUALLY TO ENSURE COMPLIANCE WITH THE PROPER SPECIFICATIONS.

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210C SERIES SIGNAL MONITOR
OPERATIONS MANUAL

Section 1
STANDARD FUNCTIONS

1.1 Introduction

This manual covers the operation, equipment usage, and design considerations of the 210C series SIGNAL MONITOR. It provides the user with a general understanding of the operating principles necessary to install and maintain the model 210C series SIGNAL MONITOR.

1.2 Standard Functions

The 210C series SIGNAL MONITOR is a device used in a traffic controller assembly to monitor traffic signals at an intersection for conflicting proceed indications caused by malfunctions of the controller, load switches, field wiring and loads, or miswiring of the cabinet. The 210C series SIGNAL MONITOR also provides error sensing of the cabinet 24VDC supply and monitors the controller Watchdog output. The 210C series SIGNAL MONITOR is directly interchangeable with a standard model 210 SIGNAL MONITOR and complies with all specifications outlined in Chapter 4 (Model 210 Monitor Specifications) of the *Traffic Signal Control Equipment Specifications* (January 1989).

When triggered by the detection of a fault condition which exists longer than the minimum period, the 210C series SIGNAL MONITOR will enter the fault mode causing the Output relay contacts to close and enabling the Stop-Time output to the controller. The cabinet assembly should be wired such that the closure of the conflict monitor Output relay contacts will cause an automatic switching of the field signal outputs from normal operation to flashing operation. The 210C series SIGNAL MONITOR will then display the appropriate fault indications. The 210C series SIGNAL MONITOR will remain in this fault mode until a reset command is issued via the front panel RESET button or External Reset input. The loss of AC Line power will not reset the fault mode unless the fault is WDT Error, Diagnostic, or BND Fail. In the event of AC Line power loss the 210C series SIGNAL MONITOR will retain the status of all fault and channel indicators and will display the correct fault and channel status upon restoration of AC Line power.

1.2.1 Conflict Monitoring

The 210C is capable of monitoring 16 channels. Each channel monitors a Green and Yellow field signal output at the field terminals. A Program Card is provided for assigning conflicting channels and inhibiting Yellow monitoring for required channels. The 210C series SIGNAL MONITOR detects the presence of conflicting Green or Yellow signals on the AC field terminations between any two or more channels assigned to conflict on the Program Card. The monitoring circuitry is capable of detecting either full wave or positive and negative half-wave field signal outputs at the specified voltage levels.

1.2.2 24VDC Monitoring

Sensing of the cabinet 24VDC supply is provided as specified in Section 4.2, Chapter 4 of the *Traffic Signal Control Equipment Specifications*. When the 24VDC input falls below the specified voltage levels the 210C series SIGNAL MONITOR will enter the fault mode causing the Output relay contacts to close and enabling the Stop-Time output to the controller.

1.2.3 Controller Watchdog Monitoring

Sensing of the controller Watchdog output is provided as specified in Section 4.3, Chapter 4 of the *Traffic Signal Control Equipment Specifications*. The Watchdog output from the Controller Unit is monitored for logic transitions. When a logic transition is not sensed for the specified period (see Section 3.3.2) the 210C series SIGNAL MONITOR will enter the fault mode causing the Output relay contacts to close and enabling the Stop-Time output to the controller. This WDT Error fault mode is latched until a Reset command is applied or AC power is removed. If the WDT Error fault mode is reset from an loss of AC power, the WDT Error LED will remain illuminated to indicate a WDT Error existed but was cleared by the power loss. A Reset command is required to clear the LED fault indication.

Section 2
EXTENDED FEATURES

The following extended features are provided on the 210C series SIGNAL MONITOR to provide additional fault monitoring functions, to increase the reliability of the monitor operation, and enhance the diagnostic capabilities offered to the service technician.

2.1 Hardware Features

The model 210C series SIGNAL MONITOR is a CMOS microprocessor based unit. All monitoring functions and features are firmware programmable which permits upgrades or modifications by simply replacing the EPROM device containing the firmware with the upgraded version. Thus, most changes to the 210C series SIGNAL MONITOR specifications may be accommodated without modifying the hardware.

Since all critical timing functions are accomplished by the microprocessor, the quartz crystal based accuracy results in very precise and repeatable measurements. This accuracy is maintained on functions from timing fault conditions to implementing a unique firmware based digital sampling and filtering algorithm. This algorithm is applied to all AC field signals to help eliminate false detection in a "noisy" AC line environment.

The use of voltage comparators for detecting field signal output status provides precise voltage level sensing of the field signals. Voltage references are temperature compensated for constant voltage levels within the operating temperature range.

A nonvolatile EEPROM device is utilized to retain fault status information in the event of an AC Line power interruption. The correct fault indications will be displayed upon restoration of AC Line power. This EEPROM device requires no battery back-up.

2.2 AC Line Brown-out Detection

When the AC Line voltage is below the "drop-out" level the 210C series SIGNAL MONITOR will suspend all fault monitoring functions, close the Output relay contacts, and enable the Stop-Time output to the controller. This condition is maintained for a minimum period of 4.25 seconds. The AC indicator on the front panel will flash at a rate of 2Hz to indicate the brown-out status.

When the AC Line voltage returns above the "restore" level the monitor will resume normal operation and the AC power indicator on the front panel will remain illuminated.

2.3 Non-Volatile Fault Memory

The loss of AC Line power to the monitor will not reset the following fault conditions: VDC Failed, Conflict. The 210C series SIGNAL MONITOR stores the fault and channel indicator status at the time the fault occurs into a non-volatile EEPROM device. Should an AC Line power interruption occur while the monitor is in the fault mode, then upon restoration of AC Line power, the Output relay and Stop-Time output will remain in the fault mode and the correct fault and channel indicators will be illuminated. This fault mode is maintained until the monitor is Reset. If the AC Line voltage level falls below the Watchdog Disable level, a Watchdog Error will be reset when the AC Line voltage level returns above Watchdog Enable level. A BND fault will also be reset by an AC Line brown-out or dropout.

2.4 PCA (Program Card Absent) Indication

If the Program Card is absent or not seated properly in the edge connector, the 210C series SIGNAL MONITOR will enter the fault mode causing the Output relay contacts to close and enabling the Stop-Time output to the controller. The PCA indicator will illuminate to indicate this condition. A manual or external Reset is required after the Program Card is properly seated.

2.5 Internal Watchdog

The 210C series SIGNAL MONITOR generates an internal watchdog pulse from its microprocessor. This occurs at least once per line cycle. If the internal hardware does not detect a watchdog pulse within approximately 200 milliseconds, the 210C series SIGNAL MONITOR will enter the fault mode causing the Output relay contacts to close and enabling the Stop-Time output to the controller. The DIAGNOSTIC indicator on the front panel will illuminate to indicate a monitor hardware and/or firmware failure.

This type of failure is configured as non-latching. If the microprocessor resumes operation the unit may return to normal operation. If latching operation is desired, jumper E11 may be inserted. With latching operation, only a loss of AC Line will restore operation. See Section 3.4.

2.6 Reset Input Detection

A reset command from either the front panel Reset button or External Reset input will cause a one-time 300 millisecond reset command to the monitor. If the reset command is maintained longer than 300 milliseconds, the monitor will resume monitoring functions and the Reset command will then provide input to the Diagnostic Display mode (see Section 2.12).

2.7 LED Test

The monitor will illuminate all front panel indicators for 300 milliseconds when a Reset command is issued by the front panel Reset button or External Reset Input. This function provides a way to check the operation of all front panel indicators.

2.8 Memory Test

The 210C series SIGNAL MONITOR verifies the proper operation of the memory devices (RAM, EPROM, & EEPROM) required to operate the monitor. This test is performed when AC Line power is applied, a Reset Command is issued to the monitor, and periodically during operation. If a memory error is detected, the 210C series SIGNAL MONITOR will attempt to update the front panel display and then execute a STOP instruction. This will cause the Output relay contacts to close and enable the Stop-Time output to the controller. The DIAGNOSTIC indicator on the front panel will illuminate to indicate a monitor hardware and/or firmware failure. As a possible aid to the service technician the channel status indicators may display a code to indicate which memory device is failing. However, due to the nature of this failure mode, these indicators should be used only as a guide.

Memory Failure Indicators
Channel #1 status indicator: MPU on-chip memory (U32)
Channel #2 status indicator: static ram device (U27)
Channel #3 status indicator: eprom device (U33)
Channel #4 status indicator: eeprom device (U38)

2.9 Watchdog Monitoring Disabled Indicator

When the WDT ENABLE switch is in the OFF position to disable Watchdog Monitoring of the cabinet Controller, or the AC Line voltage is below the Watchdog disable level, the 210C series SIGNAL MONITOR will flash the WDT ERROR indicator on the front panel once every 2 seconds. This function informs the service technician that the cabinet Controller Watchdog monitoring function is disabled.

2.10 Internal Power Supply Monitoring

This function facilitates the orderly initialization or "shut-down" of the 210C series SIGNAL MONITOR microprocessor. If the internal unregulated DC supply falls below 8 $\pm$1 Vdc, the microprocessor is placed in reset to suspend the execution of the firmware program. The 210C series SIGNAL MONITOR will enter the fault mode causing the Output relay contacts to close and enabling the Stop-Time output to the controller. The DIAGNOSTIC indicator on the front panel will illuminate to indicate a monitor hardware and/or firmware failure.

When the voltage level goes above 11 $\pm$1 Vdc, the reset is removed from the microprocessor which enables it to initialize and execute the program loop. This internal power supply monitoring insures that normal operation of the

microprocessor only occurs when the internal power supply of the 210C series SIGNAL MONITOR is at the required voltage levels.

2.11 BND (Blinking/Noise/Dimming) Error Detection

This error detection function supplements the unique firmware sampling and digital filtering method for sensing the field input signals. The 210C unit field input sensing algorithm is designed to filter out relatively short term noise transients commonly found on the electrical service and provide noise immunity against false signal detections. The BND Error Detection function is designed to detect and respond to irregular input waveforms which exhibit a longer time constant in comparison to the short term digital filtering time constant. This detection algorithm is intended to detect a signal that is: irregularly **B**linking (flickering); has constant extraneous **N**oise; or is **D**immed invalidly under Controller Unit software control. These signals are differentiated in part due to the large time constants which may be associated with these irregular input waveforms and may indicate a malfunctioning component or improper operating mode within the cabinet assembly.

The BND Error Detection function is designed to recognize many of these possible input waveforms and will place the 210C unit into the fault mode. If the aforementioned signal conditions exist for a pre-determined period of time, the 210C unit will enter the fault mode, transfer the Output relay contacts to the Fault position, enable the Stop-Time output to the controller, and illuminate the BND FAIL indicator. The Channel Status display will indicate the channels on which the fault occurred. The 210C unit will remain in the fault mode until the unit is reset by the Reset button or the External Reset input. An AC Line brown-out condition or a complete loss of AC Line power will reset the BND fault state of the monitor.

2.11.1 Blinking

This blinking or flickering signal condition may exist under certain abnormal circumstances such as: controller output malfunction (i.e. output toggling, pinwheeling, etc.); load switch malfunction (output shorting intermittently, zero cross failure, phase firing, etc.); intermittent field wiring or Neutral return (due to corrosion, poor termination, improper or poor cabinet grounding system, etc.). Another cause of flickering occurs when excessive AC voltage to a channel input in the OFF state occurs due to load switch "leakage current" and high load impedance. This high impedance load may be caused by dimmers, low wattage loads (7 watt test lamps, solid state loads, etc.), poor wire terminations, etc.. When the voltage level of a field input signal is near the threshold level of the input comparators, AC ripple and noise may produce a flickering effect.

NOTE: When the voltage level of a field input signal is reduced to within approximately 100 mV of the threshold level of the input comparators, the front panel channel indicators may flicker due to ac ripple and cause a BND error to be detected. This input threshold level may lie between 17Vrms and 23Vrms. The *Traffic Signal Control Equipment Specification* states that the input monitoring circuitry may or may not detect within a voltage range of 15Vrms to 25Vrms. To assist in testing and calibration a "BND Test Disable" option can be used to disable the BND function (see Section 3.2.1). This is for test purposes only. For the broadest fault coverage the 210C series SIGNAL MONITOR should not be operated with the BND function disabled.

2.11.2 Noise

Constant high energy noise or transients on the field signal inputs may affect the integrity of the input sample if it occurs exactly within the narrow sampling "window" of the 210C unit. Depending on the severity and repetition rate of the input noise, a BND error may be detected after the samples have been corrupted for a continuous period of 90 to 200 line cycles.

This condition may not always be due to extraneous input noise. A faulty input comparator device may also result in reading invalid sampling data.

2.11.3 Dimming

The sampling and filtering algorithm allows only half wave (positive or negative) suppressed dimming. Other dimming waveforms may be achieved under cabinet controller software control and will be detected as a BND error within approximately 90 periods of the input waveform.

2.12 Diagnostic Display Mode

The 210C series SIGNAL MONITOR provides two means of displaying the individual Green and Yellow field status. The No Fault Diagnostic Display mode shows the active channels for each color while the monitor is not in the fault mode (intersection operating). The Fault Diagnostic Display mode shows the active channels for each color which were active at the time the monitor triggered to the fault mode (intersection in flash). The Fault Diagnostic Display mode also provides a review of previous fault events.

2.12.1 No Fault Diagnostic Display

When the 210C series SIGNAL MONITOR is not in the fault state, the unit can display the active Green and Yellow field status individually. To enter this display mode depress and hold the Reset button. Each time the Reset button is activated and held, the next set of colors will be displayed on the channel status indicators. The display will continue to show the selected color as long as the Reset button is activated. This mode only affects the monitor display and normal fault processing will continue to occur. The sequence is as follows:

Reset	Fault Status LEDs	Channel Status LEDs
#1	(G) AC POWER LED flashes	Green field status 1-16
#2	(Y) VDC FAILED LED flashes	Yellow field status 1-16
...	(repeats back to top)	

2.12.2 Fault Diagnostic Display

Once the 210C series SIGNAL MONITOR has been triggered by a fault, the Green and Yellow field input status active at the time of the current fault and the two previous faults may be displayed individually. This status is not reset by an AC Line power interruption. To enter this display mode remove the Program Card. The sequence is as follows:

Reset	Event	PCA LED	Fault Status LEDs	Channel Status LEDs
---	#1	Single flash	Current Fault Status (newest)	Current channel status
#1	#1	Single flash	(G) AC POWER LED flashes	Green field status 1-16
#2	#1	Single flash	(Y) VDC FAILED LED flashes	Yellow field status 1-16
#3	#2	Double flash	Event #2 Fault Status	Event #2 channel status
#4	#2	Double flash	(G) AC POWER LED flashes	Green field status 1-16
#5	#2	Double flash	(Y) VDC FAILED LED flashes	Yellow field status 1-16
#6	#3	Triple flash	Event #3 Fault Status (oldest)	Event #3 channel status
#7	#3	Triple flash	(G) AC POWER LED flashes	Green field status 1-16
#8	#3	Triple flash	(Y) VDC FAILED LED flashes	Yellow field status 1-16
...			(repeats back to top)	

To enter this display mode remove the Program Card. Depressing the Reset button advances the display mode from the normal mode to the Green field input display. The (G) AC POWER LED will pulse ON once per second to indicate this mode. The channel display LEDs will show the Green channels active at the time of the fault. The PCA LED will pulse once per second to indicate the current fault (#1, newest).

Depressing the Reset button again advances the display mode from the Green display mode to the Yellow field input display. The (Y) VDC FAIL LED will pulse ON once per second to indicate this mode. The channel display LEDs will show the Yellow channels active at the time of the fault.

Depressing the Reset button again advances the display mode from the Yellow display mode (of fault #1) to the fault display mode for fault #2. The PCA LED will pulse twice per second to indicate the previous fault (#2). Additional button closures will cycle through the colors for fault #2 and fault #3 (oldest). After the Yellow display for fault #3, the display will return to fault #1.

To exit this display mode, replace the Program Card. If the Program Card is removed while the model 210C unit has **not** been triggered by a fault, the fault status display mode will show the Green and Yellow channels active when the Program Card was removed. If a PCA fault is displayed during the review, the PCA LED will not flash during the Fault Status display step to indicate the fault number.

Section 3
INSTALLATION

3.1 Program Card Programming

This card provides the means to assign conflicting channels and to disable sensing of Yellow input signals. The card is initially supplied with 120 diodes mounted on the card. This permits all channels to conflict with all other channels. To program a NON-CONFLICTING channel pair, remove the appropriate diode from the program card. To DISABLE sensing of a Yellow signal on a channel, solder a wire jumper between the hole pairs labeled for that channel.

Example: If channel 2 Green or Yellow is permissive with channel 6 Green or Yellow, disconnect the diode labeled "2-6". To disable Yellow signal sensing on channel 9, a jumper wire must be soldered in between the pair of holes labeled "9" in the area designated "YELLOW DISABLE" on the program card.

If the Program Card is removed or not seated properly in the edge connector, the 210C series SIGNAL MONITOR will enter the fault mode causing the Output relay contacts to close and enabling the Stop-Time output to the controller. The PCA indicator will illuminate to indicate this condition. A manual Reset is required after the Program Card is properly seated.

3.2 Option Programming

The 210C series SIGNAL MONITOR provides one option to modify the monitor operation. The option jumpers are labeled SW-3 and are located near the WD ENABLE toggle switch.

3.2.1 BND Disable Jumper

Position #1 of SW-3 is labeled "BND DISABLE". When a soldered wire jumper is in place, BND Error Detection is DISABLED. To assist in testing and calibration this jumper can be used to disable the BND function. This is for test purposes only. For the broadest fault coverage the 210C series SIGNAL MONITOR should not be operated with the BND function disabled.

3.3 Watchdog Programming

3.3.1 Watchdog Enable Switch

The toggle switch SW-2 labeled "WD ENABLE" provides control for the Watchdog Monitoring function. When the switch is in the ON position, the Watchdog Monitoring function is enabled. When the switch is in the OFF position, the Watchdog Monitoring function is disabled. The WDT ERROR LED will flash once every two seconds to indicate that Watchdog Monitoring is disabled.

3.3.2 Watchdog Timing Option

The fault timing value for Watchdog Monitoring can be selected as 1.5 seconds or 1.0 seconds. Diode CR28 (1N4148B) labeled "WD SEL" is located below the WD ENABLE switch. When diode CR28 is absent, the Watchdog timing value defaults to 1.5 seconds. When diode CR28 is present, the Watchdog timing value is set to 1.0 seconds.

3.4 Internal MPU Watchdog Latch Option

The internal MPU Watchdog circuit can be configured as a latching function. To enable the latching function a soldered wire jumper should be placed into jumper holes labeled "E11". See Section 2.5.

Section 4
FRONT PANEL DESCRIPTION

4.1 Indicators

(G) AC POWER Indicator

The AC POWER indicator will illuminate when AC Line voltage level is above the brown-out "restore" level. It will flash at a rate of 2Hz when the AC Line voltage is below the "drop-out" level. The indicator will extinguish when the AC Line voltage is no longer sufficient to provide the DC voltages necessary for proper monitor operation (approximately 60 Vrms).

If the unit is in the Diagnostic Display mode, the AC POWER indicator will flash ON once per second to indicate the Channel Status display is showing Green channel status. See Section 2.12.

(Y) VDC FAILED Indicator

The VDC FAILED indicator will illuminate when a 24VDC fault condition is detected. This indicator remains extinguished if the monitor has not been triggered by a 24VDC fault. If the unit is in the Diagnostic Display mode, the (Y) VDC FAILED indicator will flash ON once per second to indicate the Channel Status display is showing Yellow channel status.

WDT ERROR Indicator

The WDT ERROR indicator will illuminate when a controller Watchdog fault is detected. If the WD ENABLE switch on the monitor is placed in the OFF position to disable Watchdog monitoring, or the AC Line voltage is below the Watchdog disable level, the WDT ERROR indicator will flash ON once every 2 seconds.

CONFLICT Indicator

The CONFLICT indicator will illuminate when a conflicting proceed signal fault is detected.

CHANNEL STATUS Indicators

During normal operation the Channel Status indicators will display all active proceed signals (Green or Yellow).

In the fault mode the Channel Status indicators will display all proceed signals active at the time of a conflicting signal fault (CONFLICT), 24VDC fault (VDC FAILED), or Watchdog fault (WDT ERROR). In the event of a BND fault only the channels on which the fault occurred will be displayed.

BND Indicator

The BND indicator will illuminate when a BND ERROR fault is detected on a channel(s).

PCA Indicator

The PCA indicator will illuminate if the Program Card is absent or not properly seated. A manual Reset is required after the program card is properly seated. If the unit is in the Diagnostic Display mode, the PCA indicator will flash ON (once, twice, or three times) to indicate the fault event number being displayed.

DIAGNOSTIC Indicator

The DIAGNOSTIC indicator will illuminate when one of the following faults are detected: Internal Watchdog fault, Memory Test fault, or Internal power supply fault. This indicator is intended to inform the service technician of a monitor hardware or firmware failure. Due to the nature of these hardware or firmware failures, other fault indicators that may be concurrently illuminated may not be valid for trouble shooting purposes. The DIAGNOSTIC indicator will also illuminate when the front panel Reset button is activated.

4.2 Front Panel Controls

RESET Button

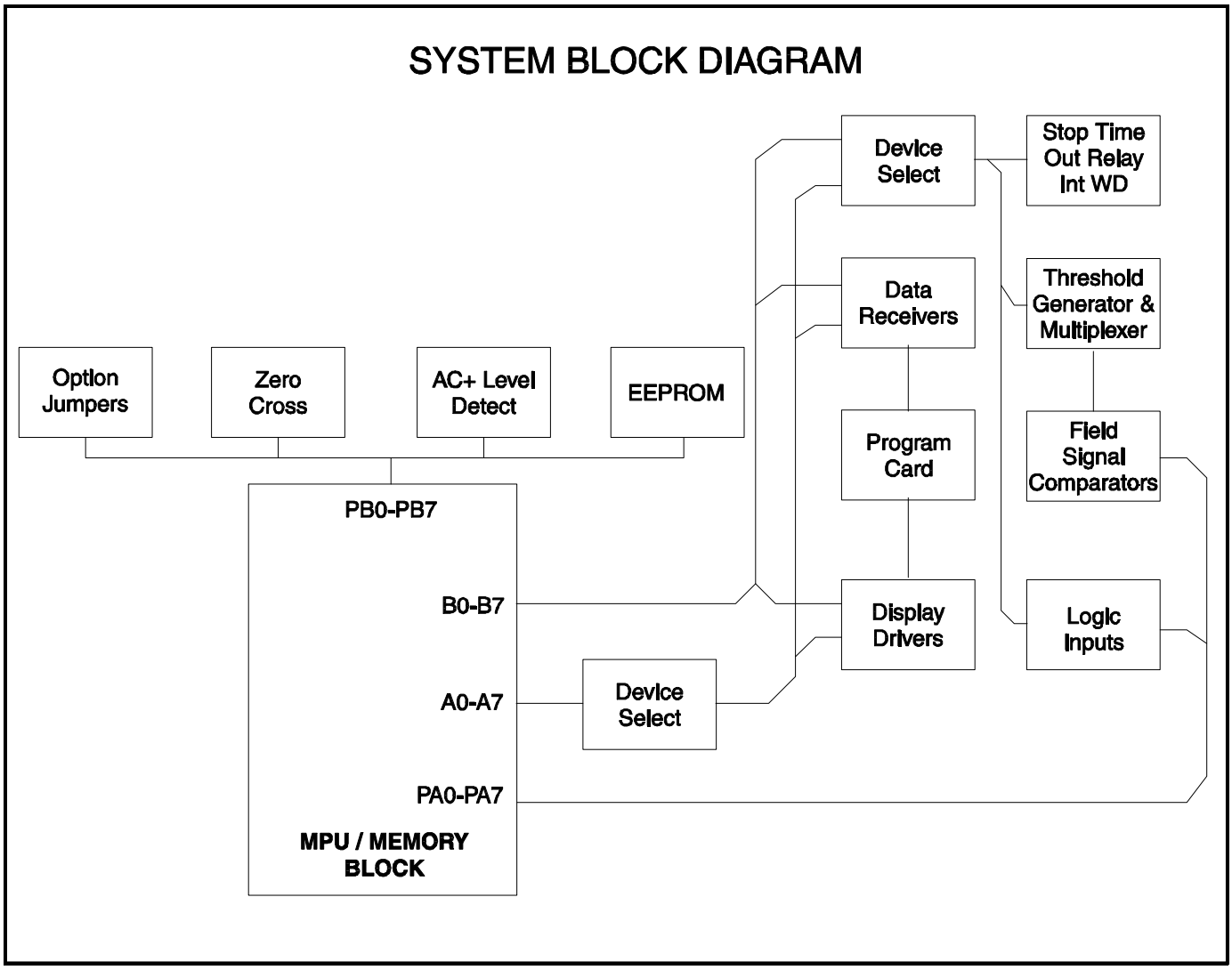
Depressing the Reset button resets the 210C series SIGNAL MONITOR after it has been triggered by a fault. The monitor will remain in the reset mode only if the fault condition has been restored to normal. In the event of a monitor hardware or firmware fault (DIAGNOSTIC) the Reset button may not reset the monitor. A power-up restart may be required.

The Reset button also provides control of the Diagnostic Display mode. For a complete description of Diagnostic Display operation see Section 2.12.

Section 5
CIRCUIT OPERATION

5.1 Introduction

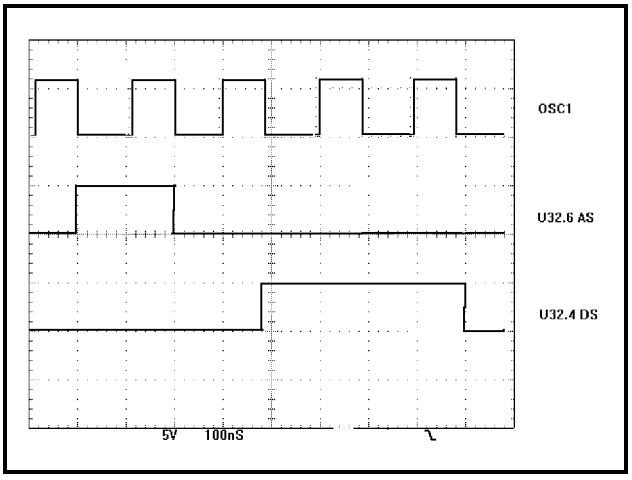
The 210C conflict monitor uses a Motorola MC146805E2CP CMOS microprocessor to execute the firmware stored on a 27C64 CMOS EPROM. Using a system of signal busses the MPU can access components such as a memory device, signal input comparators, or data latches. Each component is assigned a unique address which allows the MPU to communicate with the required component through the signal busses. Hardware on the 210C decodes these addresses and enables the required component for data transfer on the signal busses. Additional circuits include AC+ zero-cross detector, threshold generator, internal power supply monitor, voltage references, and reset.



5.2 MPU Logic Operation

The MC146805E2CP MPU (U32) has a 13-bit address bus which provides an 8K byte address range. The lower eight address lines are multiplexed with an 8-bit data bus (B0-B7). The remaining five address lines (A8-A12) are outputs only. To de-multiplex the lower eight address bits from the data bus (B0-B7), the negative edge of Address Strobe (AS) (U32.6) is used to control latch U39 to capture the lower address bits. Data Strobe (U32.4) is used to enable a selected device or component when data is to be transferred. The component may be memory (U27,33) or peripheral (latch, data buffer). The Data Strobe (DS) and Address Strobe (AS) are active every cycle when the MPU is not in STOP state.

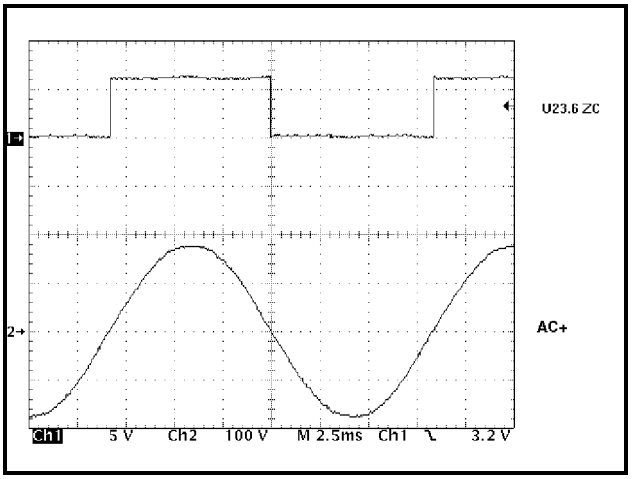
An address decoder (U20) is used to select the peripheral devices (latches and data buffers) on data bus B0-B7. It enables the required device when the Data Strobe (U32.4) is active HIGH. The R/W (Read/Write) output (U32.5) is used to control the direction of the data transfer on the data bus B0-B7. Data is written from the microprocessor to the peripheral device when R/W is LOW.



The MPU has two 8-pin
input/output ports PA and PB. Each pin can be individually programmed to be either an input or output under software control. Port A bits PA0-PA7 are programmed as an input data bus for the AC field signal comparators and the logic inputs (Watchdog and 24VDC). Port B bit PB7 (U32.29) is used to serially input or output data to the EEPROM (U38). The remaining bits of Port B are used to control and read miscellaneous signals.

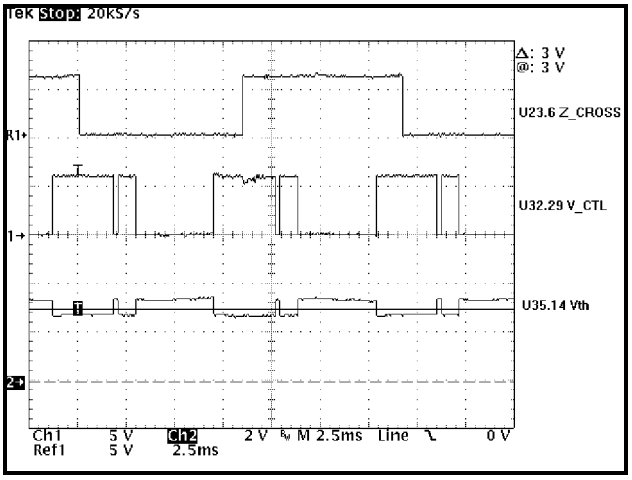
5.3 Zero-Cross Detection

This circuit generates the start of the main timing loop on the falling edge of the AC Line input. Diodes CR24 and CR25 clamp the input to normal logic levels for the inverting comparator U26B. Diode CR23 adds some hysteresis to the reference voltage of U26.7.



5.4 Threshold Generator

This circuit generates the threshold reference voltage for the AC field signal input comparators. Pin 8 of U23D is a 120 Hz wave setting the appropriate threshold polarity for positive or negative referenced samples. R48 and R49 form a voltage divider to generate a 670 mV square wave biased up to 3.0 Vdc. U35D is a voltage follower and buffer to analog multiplexer input U41.3.



5.5 Threshold Multiplexer

The analog multiplexer U41 enables six groups of eight AC field signal input comparators onto port B of the MPU (PB0-PB7). The multiplexer also enables a set of comparators that detect the presence of AC+ on the Red Enable input, Special Function inputs, and pin EE of the edgecard connector. The outputs of all the groups are connected in parallel to port B and are normally open collector until enabled onto port B. A group of comparators are enabled onto port B when multiplexer U41 applies the threshold reference voltage to the inverting inputs of the group. The outputs from latch U40 to pins 9, 10 and 11 of U41 determine which group is to be connected to the threshold reference voltage on U7.3. A group is enabled four times per half cycle or a total of 8 times per line cycle.

5.6 AC Field Input Signal Detection

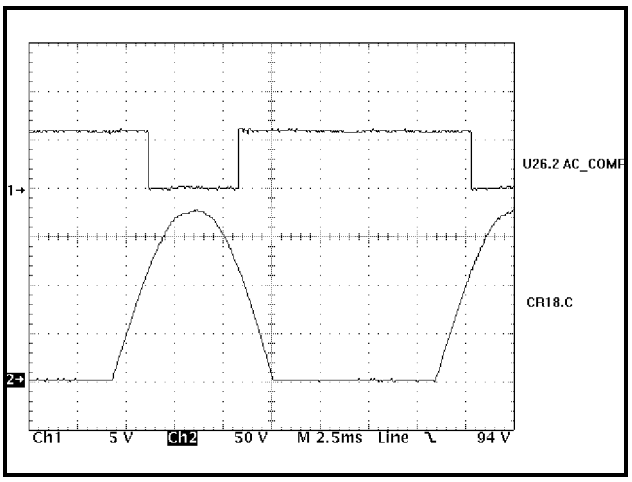
All AC field signals (Green, Yellow and Red) are voltage divided down and biased to a 3.0 Vdc reference allowing both halves of the sine wave to be sampled and tested. These signals are connected to the non-inverting inputs of the AC field input signal comparators. When the comparators are enabled by multiplexer U7 during the positive half cycle, a HIGH level on the comparators output indicates an input above the "ON" level at the appropriate full or half wave sampling time. During the negative half cycle, a comparator output LOW level indicates an input above the "ON" level at the appropriate full or half wave sampling time.

5.7 VREF1 3.0 Vdc Source

This circuit supplies the 3.0Vdc bias voltage for the AC field input voltage dividers. The circuit is a feedback regulator using operational amplifier U35B. The 1% tolerance resistors R55 and R58 voltage divide the 6.0 Vdc power supply to 3.0 Vdc which is connected to the non-inverting input of U35.5. Resistor R59 provides feedback from the regulated output to the inverting input of U35.6. Transistors Q2 and Q3 form a push-pull output driven by U35.7.

5.8 AC Line Voltage Level Detect

This circuit is used to determine the AC Line voltage level. The comparator output U26.2 generates an input which is sampled by the MPU (U32.31). AC Line is positive half wave rectified by CR18 and voltage divided down by resistors R39 and R38. The comparator reference voltage is set by a temperature stable 2.5 Vdc source (VR1) biased by resistor R37. R40 and R45 provide hysteresis to the inverting input of U26A.



5.9 Non-volatile Memory

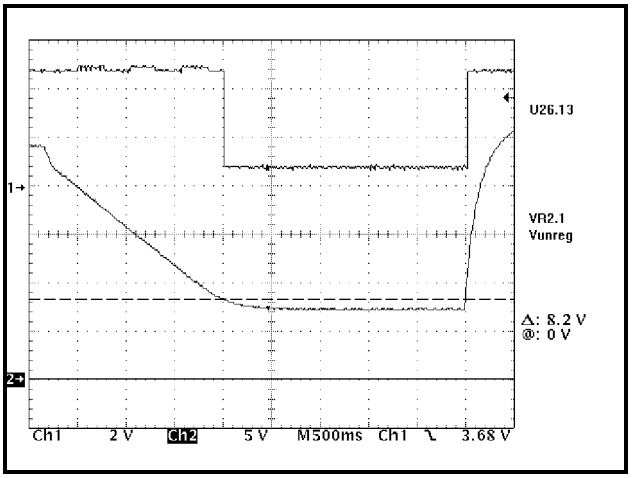
The EEPROM U38 is used to store fault status and display indications when a fault is detected. In the event of an AC Line power failure the fault and display status is recalled from the EEPROM when AC Line power is restored to the monitor. The EEPROM is clocked and enabled by latch U40 pins 15 and 6 respectively. Data is transmitted serially from PB7 of the MPU (U32.29) to pins 3 and 4 of the EEPROM.

5.10 Reset Circuit

This circuit generates an input to reset the MPU through the front panel Reset button or the External Reset input. The External Reset input is optically coupled by U58. The output of U58 is in parallel with the front panel reset button (SW1). Either reset input will place a logic LOW to the input of inverter U23.3. U23.4 will drive PB0 of the MPU (U32.36). The output of inverter U23.4 will also cause the DIAGNOSTIC indicator LED (DS5) to illuminate through diode CR11. This tests the indicator during a manual reset LED test.

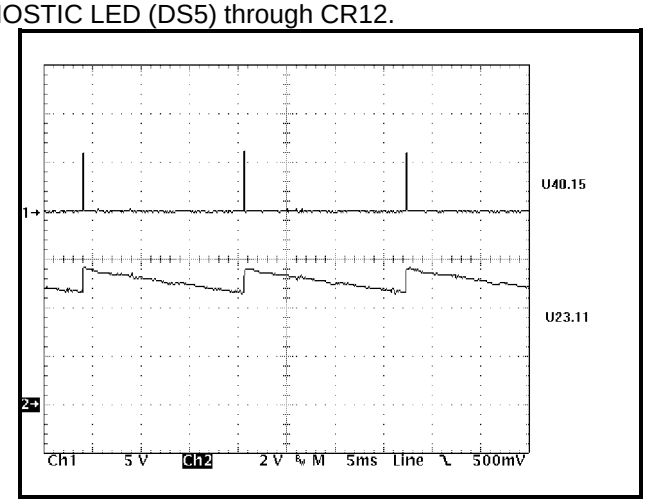
5.11 Internal DC Supply Monitor

This circuit holds the MPU in reset if the internal unregulated supply is not above the required operating levels. The op-amp U26D is used as a non-inverting voltage comparator. The inverting input U26.10 is connected to the 2.5 Vdc reference VR1. Resistors R50 and U46.9 voltage divide the unregulated DC supply to U26.11. Resistor R54 provides hysteresis for the circuit so that when the unregulated DC supply falls below 8 $\pm$1Vdc, the output will be at a logic LOW and reset the MPU. When the unregulated supply goes above 11 $\pm$1Vdc, the output (U26.13) will be at a logic HIGH. The U35C logic HIGH also provides anode drive for the AC POWER LED (DS1).



5.12 Internal Watchdog Monitor

This circuit monitors the watchdog pulses generated by the MPU through latch U40.15. This pulse occurs once per line cycle and is continuous when the MPU is not in the STOP mode. The watchdog pulses are capacitively coupled to inverter U23.11 by C33. The output of the inverter U23.12 will charge capacitor C29 through CR14. Capacitor C29 will discharge through R32 until the next pulse is detected. The output of inverter U23.2 is a logic LOW as long as C29 is charged HIGH. If a watchdog pulse is not detected within 200 milliseconds, C29 will discharge below the logic HIGH threshold and the output of inverter U23.2 will disable the Output relay K1, enable the Stop Time output through U76, and illuminate the DIAGNOSTIC LED (DS5) through CR12.



5.13 Fault and Channel Displays

The fault and channel status indicators are driven by 8-bit latches U34, U43, U36. The inputs of these latches are connected to the MPU data bus (B0-B7) and are enabled by address decoder U20.

5.14 Program Card

The outputs of channel status latches U43 and U36 also drive the anodes of the program card diode matrix through the edge card connector P4. The data at the cathode side of the program card is "read" by the MPU through data buffers U45 and U47. Data buffers U49 and U51 are used to input the status of the Yellow Inhibit jumpers on the program card. Data buffers U52 and U53 are used to input the status of the SSM switches (SW4,5).

5.15 24VDC Monitor

The 24VDC level detection is done with a voltage comparator U71B. The output of U71.1 is connected to the diode side of isolator U56.2. Resistors R67 and R69 voltage divide the 24VDC to the inverting input of U71.6. Components R65, CR36 and Q4 generate a compensated reference to comparator U71B. Resistors R64 and R66 add hysteresis. If the 24 Vdc supply falls below 19.5 Vdc the output of U71.1 will be approximately 19.0 Vdc. The output side of U56 will be in the OFF state. If the 24 Vdc supply goes above 20.0 Vdc, U71.1 will be at DC ground. The output side of U56 will be in the ON state. The output side of U56.5 is connected to PA0 of the MPU (U32.14). The collector is enabled on the PA signal bus only when the emitter U56.4 is enabled by AUX_EN signal U32.34. A logic LOW on the collector of U56 when the emitter is enabled indicates that the 24 Vdc supply is above the operating level.

5.16 Watchdog Monitor

The Controller Watchdog input is connected through comparator U71A to the diode side of optical isolator U57.2. When the Watchdog input is less than 7.5 Vdc, the comparator U71.2 output goes LOW and turns on the output transistor of U57. The collector of the output side of U57.5 is connected to PA1 of the MPU (U32.13). The collector is enabled on the port A signal bus when the emitter of U57.4 is forced LOW by AUX_EN signal U32.34. The MPU will sample the Watchdog input every line cycle and monitor for the required logic transitions.

Section 6
TROUBLE SHOOTING

SYMPTOMS:

Will not power on

CAUSES:

A) Blown fuse
B) Internal power supply is low
C) No AC input to the monitor

SOLUTIONS:

A) Remove the fuse and verify with an Ohm meter. Replace if necessary with a fuse with the same current rating.
B) Check the unregulated voltage across filter capacitor C41 with an oscilloscope or volt meter. It should read between 20 and 25 Vdc when the AC Line is equal to or greater than 110 Vrms. If the unregulated supply is less than 8 Vdc the internal power supply monitoring circuit will hold the MPU in reset and the DIAGNOSTIC indicator on the front panel should illuminate. Measure the regulated voltage across capacitor C36. If it measures lower than 6 $\pm$0.5 Vdc when the unregulated supply is 8 Vdc or greater, the regulated supply may be overloaded or shorted to ground.
C) If the fuse is not blown then the monitor may not be getting AC Line or Neutral to the edge connector of the monitor.

SYMPTOMS:

Faults when AC power is applied

CAUSES:

A) Program card is absent or not seated properly
B) AC Line level is low
C) Memory device fault
D) No zero-cross input to MPU
E) No internal watchdog pulses

SOLUTIONS:

A) The PCA indicator on the front panel will illuminate. Re-insert the program card with the diode side of the card facing the front panel slot labeled DIODE SIDE and depress the RESET switch. The rear edge of the program card should be flush with the front panel.
B) Measure the AC Line voltage level with a volt meter. If it is below the required "drop-out" level, the monitor will transfer the Output relay contacts and enable the STOP TIME output to the controller. The AC POWER indicator on the front panel will flash at a rate of 2 Hz to indicate the "brown-out" condition.
C) The memory devices are verified when AC Line power is applied or a Reset command is issued. **If a memory fault is detected the MPU executes a STOP instruction.** This causes all MPU activity to cease. Refer to Section 2.8.
D) Absence of a zero-crossing input will cause the Output relay contacts to transfer and enable the STOP TIME output. The DIAGNOSTIC indicator on the front panel will illuminate. Refer to the Zero-cross Detection Section 5.3 for the necessary waveforms.
E) Absence of internal watchdog pulses may be due to the following conditions: the MPU is not executing or completing the program loop; no zero crossing input; or the hardware to detect the internal watchdog pulses is not functioning.

   Place an oscilloscope probe on U40.15. Refer to the Internal Watchdog Monitor Section 5.12 for the corresponding waveforms. If there are no pulses, depress the front panel reset switch to re-start the MPU. If the pulses do not resume then check the zero crossing input to the MPU U32.32. If the watchdog pulses are now present on U40.15 then trace the remaining pulse detection hardware for the required waveforms.

SYMPTOMS:

Required channels will not conflict

CAUSES:

Diode on the Program Card is open or absent

SOLUTIONS:

Check the program card to verify that the required diode is in place. If the diode is present then place a scope probe or meter probe on the cathode of the diode. This point should be a logic HIGH when the required channels are in conflict.

Section 7
SPECIFICATIONS

7.1 Electrical

7.1.1 Power Requirements

Operating Line Voltage	75 to 135 Vrms
Operating Line Frequency	60 ±3Hz
Power Consumption	5W (nominal)

7.1.2 AC Voltage Monitors

Green Signal Inputs	(no detect)	less than 15 Vrms*
	(detect)	greater than 25 Vrms*
Yellow signal Inputs	(no detect)	less than 15 Vrms*
	(detect)	greater than 25 Vrms*
Watchdog Enable (AC level)	(enable)	greater than 103 ±2 Vrms
	(disable)	less than 98 ±2 Vrms
AC Line Brown-out	(drop out)	82 ±2 Vrms
AC Line Brown-out	(restore)	87 ±2 Vrms

7.1.3 DC Voltage Monitors

+24VDC Input	(fault)	less than +18 Vdc
	(no fault)	greater than +22 Vdc
External Reset Input	(TRUE)	less than 3.5 Vdc
	(FALSE)	greater than 8.5 Vdc
Watchdog Input	(TRUE)	less than 3.5 Vdc
	(FALSE)	greater than 8.5 Vdc

* Positive or negative half wave input.

7.2 Timing Functions

Conflict	(no fault)	less than 200 milliseconds
	(fault)	greater than 500 milliseconds
	(typical)	350 milliseconds
VDC Failed	(no fault)	less than 200 milliseconds
	(fault)	greater than 500 milliseconds
	(typical)	400 milliseconds
Watchdog	(no fault)	less than 900 milliseconds
	(fault)	greater than 1600 milliseconds
	(typical)	1000 or 1500 milliseconds
Brown-out	(drop out)	83 $\pm$17 milliseconds
Brown-out	(restore)	83 $\pm$17 milliseconds
Minimum flash after enable		4.25 seconds
Watchdog	(disable)	83 $\pm$17 milliseconds
Watchdog	(enable)	83 $\pm$17 milliseconds

7.3 Mechanical

Height	9.3 inches
Width	1.38 inches
Depth	10.17 inches

7.4 Environmental

Storage Temperature Range	-55 to +90 ^{o}C
Operating Temperature Range	-37 to +74 ^{o}C
Humidity Range	0 to 95% Relative

Section 8
WIRING ASSIGNMENTS

8.1 Monitor Unit Connector (P3)

PIN	FUNCTION	PIN	FUNCTION
1	CHANNEL 2 GREEN	A	CHANNEL 2 YELLOW
2	CHANNEL 13 GREEN	B	CHANNEL 6 GREEN
3	CHANNEL 6 YELLOW	C	CHANNEL 15 GREEN
4	CHANNEL 4 GREEN	D	CHANNEL 4 YELLOW
5	CHANNEL 14 GREEN	E	CHANNEL 8 GREEN
6	CHANNEL 8 YELLOW	F	CHANNEL 16 GREEN
7	CHANNEL 5 GREEN	H	CHANNEL 5 YELLOW
8	CHANNEL 13 YELLOW	J	CHANNEL 1 GREEN
9	CHANNEL 1 YELLOW	K	CHANNEL 15 YELLOW
10	CHANNEL 7 GREEN	L	CHANNEL 7 YELLOW
11	CHANNEL 14 YELLOW	M	CHANNEL 3 GREEN
12	CHANNEL 3 YELLOW	N	CHANNEL 16 YELLOW
13	CHANNEL 9 GREEN	P	NOT ASSIGNED
14	NOT ASSIGNED	R	CHANNEL 10 GREEN
15	CHANNEL 11 YELLOW	S	CHANNEL 11 GREEN
16	CHANNEL 9 YELLOW	T	NOT ASSIGNED
17	NOT ASSIGNED	U	CHANNEL 10 YELLOW
===		===	
18	CHANNEL 12 YELLOW	V	CHANNEL 12 GREEN
19	NOT ASSIGNED	W	NOT ASSIGNED
20	CHASSIS GROUND	X	NOT ASSIGNED
21	AC-	Y	DC GROUND
22	WATCHDOG TIMER	Z	EXTERNAL RESET
23	+24VDC	AA	+24VDC
24	[PINS 24 AND 25]	BB	STOP TIME
25	[ARE TIED TOGETHER]	CC	NOT ASSIGNED
26	NOT ASSIGNED	DD	NOT ASSIGNED
27	NOT ASSIGNED	EE	OUTPUT SW, SIDE #2
28	OUTPUT SW, SIDE #1	FF	AC Line

NOTE: Pins 23 and AA are shorted together. Maximum current rating is 500 milliamps. Pins 24 and 25 are shorted together. The Monitor circuit and the Program Card mate with a 28/56 pin double sided edgecard connector having .156 " centers.

(=== Position for key slot)

8.2 Program Card Connector (P4)

PIN	FUNCTION (COMPONENT SIDE)	PIN	FUNCTION (CIRCUIT SIDE)
1	CHANNEL 2 GREEN	A	CHANNEL 1 GREEN
2	CHANNEL 3 GREEN	B	CHANNEL 2 GREEN
3	CHANNEL 4 GREEN	C	CHANNEL 3 GREEN
4	CHANNEL 5 GREEN	D	CHANNEL 4 GREEN
5	CHANNEL 6 GREEN	E	CHANNEL 5 GREEN
6	CHANNEL 7 GREEN	F	CHANNEL 6 GREEN
7	CHANNEL 8 GREEN	H	CHANNEL 7 GREEN
8	CHANNEL 9 GREEN	J	CHANNEL 8 GREEN
9	CHANNEL 10 GREEN	K	CHANNEL 9 GREEN
10	CHANNEL 11 GREEN	L	CHANNEL 10 GREEN
11	CHANNEL 12 GREEN	M	CHANNEL 11 GREEN
12	CHANNEL 13 GREEN	N	CHANNEL 12 GREEN
13	CHANNEL 14 GREEN	P	CHANNEL 13 GREEN
14	CHANNEL 15 GREEN	R	CHANNEL 14 GREEN
15	CHANNEL 16 GREEN	S	CHANNEL 15 GREEN
16	DC GROUND	T	CONFLICT
17	CHANNEL 1 YELLOW	U	CHANNEL 9 YELLOW
18	CHANNEL 2 YELLOW	V	CHANNEL 10 YELLOW
19	CHANNEL 3 YELLOW	W	CHANNEL 11 YELLOW
20	CHANNEL 4 YELLOW	X	CHANNEL 12 YELLOW
21	CHANNEL 5 YELLOW	Y	CHANNEL 13 YELLOW
22	CHANNEL 6 YELLOW	Z	CHANNEL 14 YELLOW
23	CHANNEL 7 YELLOW	AA	CHANNEL 15 YELLOW
24	CHANNEL 8 YELLOW	BB	CHANNEL 16 YELLOW
===		===	
25	N.C.	CC	N.C.
26	N.C.	DD	N.C.
27	N.C.	EE	N.C.
28	YELLOW INHIBIT COMMON	FF	N.C.

=== Mating connector shall be keyed between pins 24 and 25 and also BB and CC.

The Monitor circuit and the Program Card mate with a 28/56 pin double sided edgecard connector having 0.156" centers.