OPERATIONS MANUAL
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MODEL 210E SERIES
SIGNAL MONITOR

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

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

REV: FEB 1998

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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.

SECTION 4.1.2, SPECIAL FUNCTION INPUTS

SPECIAL FUNCTION #2 HAS BEEN DISABLED TO PROVIDE COMPATIBILITY WITH THE MT-180 MONITOR TESTER. RESISTOR R18 HAS BEEN REMOVED TO DISABLE THIS CIRCUIT. IF SPECIAL FUNCTION #2 INPUT IS REQUIRED, R18 (150K OHMS, 1/2W) SHOULD BE INSTALLED.

- WARNING -
THE P1 RED INTERFACE CABLE SHOULD ALWAYS BE UNPLUGGED BEFORE REMOVING THE UNIT FROM THE CABINET TO PREVENT POTENTIAL EXPOSURE TO ELECTRICAL SHOCK.

TABLE OF CONTENTS

Section 1
STANDARD FUNCTIONS

1.1 Introduction

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

The 210E series SIGNAL MONITOR consists of three models; the 210E, the 210EC, and the 210ECL. All three units are built on the same platform with differences comprising hardware and software features. The model 210E is the base unit. The model 210EC adds an RS-232 serial port which gives the unit the capability to communicate with Controller Unit or PC based operational software for status and fault event data. The model 210ECL adds an enhanced event logging capability for full time stamped event reporting to the Controller Unit or PC based operational software. Where not specified otherwise, the information in this manual will apply to all three models. Text applying only to a specific model will be noted as such.

1.2 Standard Functions

The 210E 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 210E series SIGNAL MONITOR also provides error sensing of the cabinet 24VDC supply and monitors the controller Watchdog output. The 210E 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 210E 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 210E series SIGNAL MONITOR will then display the appropriate fault indications. The 210E 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 210E 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 210E is capable of monitoring 16 channels. Each channel monitors a Green, Yellow, and Red field signal output at the field terminals. A Program Card is provided for assigning conflicting channels and inhibiting Yellow monitoring for required channels. The 210E 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 210E 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 of the *Traffic Signal Control Equipment Specifications*. When a logic transition is not sensed for the specified period (see Section 4.5.2) the 210E 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 210E 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 210E 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 210E 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. Advanced event logging data and time of day in the model 210ECL unit is stored in a battery-backed RAM memory. Should this battery fail, only event data will be lost. No monitor configuration programming is stored in this memory.

2.2 Red Failure Monitoring

The 210E series SIGNAL MONITOR is designed to adapt Red Failure Monitoring to a conventional controller cabinet assembly. The simultaneous absence of active Green, Yellow, and Red field signal voltages on a channel places the 210E series SIGNAL MONITOR into the fault mode causing the Output relay contacts to close and enabling the Stop-Time output to the controller. Sixteen Red signal inputs, a Red Enable input, and two Special Function preemption inputs (SF1,2) are connected to the monitor via a front panel connector (P1) and ribbon cable assembly. Chassis Ground may also be connected to the unit through pin P1-4. Jumper E1 must then be inserted to complete the connection.

This monitoring function is enabled by applying AC+ to the Red Enable input (P1-20). Unused Red signal inputs must be tied to AC+ to prevent a Red Failure on those channels. **Red Failure monitoring is disabled for all channels when the Red Enable input is not active, a Preemption input (SF1,2) is active, or the EE input (MC Coil) is active.**

2.3 GYR-Dual Indication Monitoring

This monitoring function detects simultaneous indications of active Green and Yellow, Green and Red, or Yellow and Red field signal outputs on the same channel. A GYR-Dual Indication fault places the 210E series SIGNAL MONITOR into the fault mode causing the Output relay contacts to close and enabling the Stop-Time output to the controller. GYR-Dual Indication Monitoring is enabled concurrently with Sequence Monitoring on a per channel basis using the SSM switches (see Section 4.2) and requires the 210E series SIGNAL MONITOR to be adapted for Red Signal Monitoring. **GYR-Dual Indication Monitoring is disabled for all channels when the Red Enable input is not active or the EE input (MC Coil) is active.**

An open or no load condition (i.e., burned-out bulb) may be detected as an active signal due to load switch leakage current and may cause a Dual Indication fault. Dual Indication Monitoring may also anticipate a possible Conflict in the event that a proceed signal on a channel is constantly detected as active.

2.4 GY-Dual Indication Monitoring

This monitoring function detects a simultaneous indication of active Green and Yellow field signal outputs on the same channel. A GY-Dual Indication fault places the 210E series SIGNAL MONITOR into the fault mode causing the Output relay contacts to close and enabling the Stop-Time output to the controller. It does not require the monitor to be adapted for Red Signal monitoring, and is enabled by setting option switch SW3-2 labeled GY ENABLE in the ON position (see

Section 4.4.2). GY-Dual Indication Monitoring may be enabled concurrently with GYR-Dual Indication Monitoring. When GY-Dual Indication Monitoring is enabled, **all** channels will be individually monitored for simultaneous indications of active Green and Yellow field signal outputs. Any channels which have been selected for GYR-Dual Indication Monitoring will function as described above in Section 2.3.

This monitoring function is useful if the 210E series SIGNAL MONITOR is not adapted for Red Signal Monitoring as in the case of a standard 210 SIGNAL MONITOR. This also accommodates Green and Yellow Dual Indication Monitoring on a five section signal head.

2.5 Sequence (Short or Absent Yellow) Monitoring

This function detects the absence of a minimum period of active Yellow field signal output during a Green to Yellow to Red sequence. Sequence Monitoring is enabled concurrently with GYR-Dual Indication Monitoring on a per channel basis using the SSM switches (see Section 4.2) and requires the 210E series SIGNAL MONITOR to be adapted for Red Signal Monitoring. **Sequence Monitoring is disabled for all channels when the Red Enable input is not active or the EE input (MC Coil) is active.**

A Sequence (short or absent Yellow) fault condition will place the 210E series SIGNAL MONITOR into the fault mode causing the Output relay contacts to close and enabling the Stop-Time output to the controller. This occurs when a Red input signal to a channel is active following the termination of an active Yellow input signal which is less than the minimum duration including zero (i.e. skipped). The minimum yellow clearance interval is programmed from 2.7 seconds to 4.1 seconds using the option switch SW-3 (see Section 4.4.4).

2.6 AC Line Brown-out Detection

When the AC Line voltage is below the "drop-out" level the 210E 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.

Brown-out Detection is provided to prevent a dark intersection in the event a brown-out causes the cabinet controller to release control of the intersection. If this occurs and the intersection is not placed into flash, the monitor will detect a Red Failure (absence of signal) and will require a manual reset. **The "low AC Line Voltage" level on the Controller Unit should be set approximately 5 volts below the monitor drop-out level.**

2.7 Non-Volatile Fault Memory

The loss of AC Line power to the monitor will not reset the following fault conditions: VDC Failed, Conflict, Red Failure, Dual Indication, and Sequence. The 210E 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.

The model 210ECL uses a lifetime lithium battery to maintain the event log data and the time of day clock. Should this battery fail, only event data and clock functions will be lost. No monitor configuration data is stored under battery power.

2.8 PCA (Program Card Absent) Indication

If the Program Card is absent or not seated properly in the edge connector, the 210E 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.

2.9 Internal Watchdog

The 210E 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 210E 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 4.6.

2.10 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 2.17).

2.11 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.

2.12 Memory Test

The 210E 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 210E 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)

2.13 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 210E 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.

2.14 Extended Monitor Function Disabled Indicator

When any of the Extended Monitoring functions (Red Fail, or Dual Indication, or Sequence) are disabled because the Red Enable input is not active or the EE input (MC Coil) is active or a Special Function input is active, the 210E series SIGNAL MONITOR will flash the RED FAIL indicator on the front panel once every 2 seconds. This function informs the service technician that Extended Monitoring functions are disabled.

2.15 Internal Power Supply Monitoring

This function facilitates the orderly initialization or "shut-down" of the 210E 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 210E 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 210E series SIGNAL MONITOR is at the required voltage levels.

2.16 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 210E 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 210E unit into the fault mode. If the aforementioned signal conditions exist for a pre-determined period of time, the 210E 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 210E 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.

2.16.1 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 4.4.1). This is for test purposes only. For the broadest fault coverage the 210E series SIGNAL MONITOR should not be operated with the BND function disabled.

2.16.2 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 210E 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.

2.16.3 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.

2.17 Diagnostic Display Mode

The 210E series SIGNAL MONITOR provides two means of displaying the individual Green, Yellow, and Red field status. The No Fault Diagnostic Display mode shows the individual colors while the monitor is not in the fault mode (intersection operating). The Fault Diagnostic Display mode shows the individual colors 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.

2.17.1 No Fault Diagnostic Display

When the 210E series SIGNAL MONITOR is not in the fault state, the unit can display the active Green, Yellow, and Red 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
#3	(R) WDT ERROR LED flashes	Red field status 1-16
...	(repeats back to top)	

2.17.2 Fault Diagnostic Display

Once the 210E series SIGNAL MONITOR has been triggered by a fault, the Green, Yellow, and Red 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	#1	Single flash	(R) WDT ERROR LED flashes	Red field status 1-16
#4	#2	Double flash	Event #2 Fault Status	Event #2 channel status
#5	#2	Double flash	(G) AC POWER LED flashes	Green field status 1-16
#6	#2	Double flash	(Y) VDC FAILED LED flashes	Yellow field status 1-16
#7	#2	Double flash	(R) WDT ERROR LED flashes	Red field status 1-16
#8	#3	Triple flash	Event #3 Fault Status (oldest)	Event #3 channel status
#9	#3	Triple flash	(G) AC POWER LED flashes	Green field status 1-16
#10	#3	Triple flash	(Y) VDC FAILED LED flashes	Yellow field status 1-16
#11	#3	Triple flash	(R) WDT ERROR LED flashes	Red 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 to the Red field input display. The (R) WDT ERROR LED will pulse ON once per second to indicate this mode. The channel display LEDs will show the Red channels active at the time of the fault.

Depressing the Reset button again advances the display mode from the Red 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 Red 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 210E unit has **not** been triggered by a fault, the fault status display mode will show the Green, Yellow, and Red 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
EVENT LOGGING FEATURES

3.1 Basic Front Panel Fault Event Display

The model 210E, 210EC, and 210ECL all retain three fault events in nonvolatile memory which can be reviewed via the front panel display. The contents of the log and the procedure for review is described in Section 2.17.2.

3.2 Model 210EC Status/Event Reporting

The model 210EC uses the RS-232 port to communicate status to a Controller Unit operational software and event data to a PC.

3.2.1 BI Tran Systems 233 Program 210EC Monitor Status

The model 210EC status message format is compatible with BI Tran Systems Model 223 Software[1]. On request from the operational software, the model 210EC provides the current field status if no fault has triggered the monitor. If the monitor is in the fault mode, the current fault status and field input status at the time of the fault is reported. The BI Tran Systems Model 223 Software manual should be consulted for details of operation.

3.2.2 EDI ECcom 210EC Monitor Report

The EDI ECcom software package interfaces a Computer to the model 210EC. Operation of the ECcom software package is described in "*EDI ECcom Software Operations Manual*" and will not be covered in this manual. The ECcom program will display the model 210EC current status, the three fault events contained in the nonvolatile fault event log, and the current configuration of the unit. The following data is available from the model 210EC:

a) Fault Type: the fault type description.
b) Field Status: the current GYR field status if the monitor is not in the fault state or the latched field status and channel fault status at the time of the fault.
c) AC Line Voltage: the current AC Line voltage if the monitor is not in the fault state or the AC Line voltage at the time of the fault.
d) Control Input Status: the current state of the Red Enable input, EE input, and Special Function #1 and #2 inputs if the monitor is not in the fault state or the status latched at the time of the fault.
e) Previous Fault data: the fault type, field status, and AC Line voltage of the three previous faults.
f) Program Card Matrix: the permissive programming for each channel.
g) Yellow Disable Jumpers: the Yellow Disable programming for each channel.
h) SSM Switches: the SSM Switch programming for each channel.
I) Option Switches: GY Enable, BND Disable, SF Polarity, Sequence Timing.
j) Watchdog Programming: Watchdog Enable and Watchdog timing.

3.3 Model 210ECL Status/Event Reporting

The model 210ECL uses the RS-232 port to communicate status to a Controller Unit operational software and event data logs to a PC.

3.3.1 BI Tran Systems 233 Program 210ECL Monitor Status

The model 210ECL status message format and time/date message format is compatible with BI Tran Systems Model 223 Software. On request from the operational software, the model 210ECL provides the current field status if no fault has triggered the monitor. If the monitor is in the fault mode, the current fault status and field input status at the time of the fault is reported. The operational software will also periodically synchronize the model 210ECL time clock. The BI Tran Systems Model 223 Software manual should be consulted for details of operation.

3.3.2 EDI ECcom Monitor 210ECL Monitor Report

The EDI ECcom software package interfaces a Computer to the model 210ECL. The ECcom program will display the model 210ECL Status (S), Previous Fault (PF) event log, AC Line (AC) event log, Manual Reset (MR) event log, and the Configuration (CF) event log. All events are time stamped with the time and date of the event. Operation of the ECcom software package is described in "*EDI ECcom Software Operations Manual*" and will not be covered in this manual. The following data is available from the model 210ECL:

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[1] BI Tran Systems Inc., is located in Sacramento, California, telephone 916-441-0260.

General Data

a) Monitor ID#: a four digit (0000-9999) ID number may be assigned to the monitor.
b) Time and Date: each event is marked with the time and date of occurrence.
c) Event Number: identifies the record number in the log. Event #1 is the most recent event.

Current Status (S)

a) Fault Type: the fault type description.
b) Field Status: the current GYR field status if the monitor is not in the fault state or the latched field status and fault channel status at the time of the fault.
c) Cabinet Temperature: the current temperature if the monitor is not in the fault state or the latched temperature at the time of the fault.
d) AC Line Voltage: the current AC Line voltage if the monitor is not in the fault state or the AC Line voltage at the time of the fault.
e) Control Input Status: the current state of the Red Enable input, EE input, and Special Function #1 and #2 inputs if the monitor is not in the fault state or the status latched at the time of the fault.

Previous Fault (PF) Event Log

a) Fault Type: the fault type description.
b) Field Status: the latched field status and fault channel status at the time of the fault.
c) Cabinet Temperature: the current temperature if the monitor is not in the fault state or the latched temperature at the time of the fault.
d) AC Line Voltage: the current AC Line voltage if the monitor is not in the fault state or the AC Line voltage at the time of the fault.
e) Control Input Status: the current state of the Red Enable input, EE input, and Special Function #1 and #2 inputs if the monitor is not in the fault state or the status latched at the time of the fault.

AC Line (AC) Event Log

a) Event Type: describes the type of AC Line event that occurred.
   Power-up - AC on, monitor performed a cold start
   AC Off - $0 \leq$ AC Line < 80 V
   Brown-out - 80 < AC Line < drop-out level
   Restore - AC restored from AC brown-out or AC interruption (AC Off), no cold start
b) AC Line Voltage: the AC Line voltage at the time of the event.

Manual Reset (MR) Event Log

a) The monitor was reset from a fault by the front panel Reset button or External Reset input.

Configuration (CF) Event Log

a) Program Card Matrix: the permissive programming for each channel.
b) Yellow Disable Jumpers: the Yellow Disable programming for each channel.
c) SSM Switches: the SSM Switch programming for each channel.
d) Option Switches: GY Enable, BND Disable, SF Polarity, Sequence Timing.
e) Watchdog Programming: Watchdog Enable and Watchdog timing.

3.3.3 EDI ECcom Monitor 210ECL Monitor Report Examples

An example of each type of record is shown below:

1) Previous Fault (PF) Event Log

```
>> Monitor #73 Previous Fail Event Log <<
>> Downloaded at 3:01:16 PM  Monday, January 29, 1996 <<

Previous Fail Event #1 at:
   8:41:38 PM  Friday, January 26, 1996

   Fault = Red Fail Fault

   Ch:  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16
                  *
        R  R  R  .  R  R  R  .  R  R  R  R  R  .  R  .
        .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .
        .  .  .  .  .  .  .  G  .  .  .  .  .  G  .  G

                    AC Line = 119 Vac
                Temperature = 80 degrees F
                 Red Enable = Active
               MC Coil (EE) = Off
          Special Function #1 = Off
          Special Function #2 = Off
```

2) AC Line (AC) Event Log

```
>> Monitor #73 AC Line Event Log <<
>> Downloaded at 2:01:05 PM  Monday, January 29, 1996 <<

AC Event #1 at:
   2:41:30 PM  Tuesday, January 02, 1996
     Restore AC & WDT
     AC Line Voltage = 119 Vac

AC Event #2 at:
   2:41:25 PM  Tuesday, January 02, 1996
     Brownout AC & WDT
     AC Line Voltage = 85 Vac
```

4) Manual Reset (MR) Event Log

```
>> Monitor #73 Monitor Reset Event Log <<
>> Downloaded at 1:00:20 PM  Monday, January 29, 1996 <<

Monitor Reset Event #1 at:
    9:50:08 PM  Friday, January 26, 1996

Monitor Reset Event #2 at:
    2:33:39 PM  Wednesday, January 24, 1996
```

5) Configuration (CF) Event Log

```
>> Monitor #73 Configuration Log <<
>> Downloaded at 1:30:20 PM  Monday, January 29, 1996 <<

Configuration Change #1 at:
  3:23:55 PM  Friday, January 12, 1996
  Permissive Programming:
    Ch 1  with: 5  6  15
    Ch 2  with: 5  6  13 15
    Ch 3  with: 7  8  16
    Ch 4  with: 7  8  14 16
    Ch 5  with: 13
    Ch 6  with: 13 15
    Ch 7  with: 14
    Ch 8  with: 14 16
```

```
  Ch 9  with: no channels
  Ch 10 with: no channels
  Ch 11 with: no channels
  Ch 12 with: no channels
  Ch 13 with: 15
  Ch 14 with: 16
  Ch 15 with: no channels

Yellow Disable Jumpers (X=Disable):
  Ch:  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16
       .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .

SSM Switches (X=ON):
  Ch:  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16
       X  X  X  X  X  X  X  X  .  .  .  .  .  .  .  .

    BND Disable Switch = OFF
      GY Enable Switch = ON
    SF Polarity Switch = OFF
Watchdog Enable Switch = ON
 Watchdog Fault Timing = 1.5 seconds
Sequence Yellow Timing = 2.7 seconds
```

Section 4
INSTALLATION

The 210E series SIGNAL MONITOR is a plug-in module for the Type 170/179 output file. When inserted into the output file without the Red Interface cable assembly, it will operate as a standard 210 Signal Monitor.

4.1 Adapting Red Monitoring

A Red Interface Adapter PCB and an Interconnecting cable is used to adapt Red Signal Monitoring to the controller cabinet assembly. The interconnecting cable is terminated at each end with identically polarized 20 pin plugs. To connect the 210E series SIGNAL MONITOR with the adapter PCB, insert the Interconnecting cable plug into the Red Interface connector (P1) until the two ejector latches "snap" into place over the cable plugs.

- WARNING -
THE P1 RED INTERFACE CABLE SHOULD ALWAYS BE UNPLUGGED BEFORE REMOVING THE UNIT FROM THE CABINET TO PREVENT POTENTIAL EXPOSURE TO ELECTRICAL SHOCK.

4.1.1 Red Field Inputs

The pins numbered 1,2,3,5,7, and 9 through 19 of the Red Interface connector P1 correspond to Red channel inputs on the 210E series SIGNAL MONITOR. **All unused Red channel inputs must be terminated to AC+.** Pin #20 of P1 is the Red Enable input and must be active to enable Red Failure Monitoring, GYR-Dual Indication Monitoring, and Sequence Monitoring. The Red Enable input is normally connected to the load switch AC+ buss in order to disable Red Failure Monitoring, GYR-Dual Indication Monitoring, and Sequence Monitoring when the intersection is in hardware flash.

4.1.2 Special Function Preempt Inputs (SF1,2)

The pins numbered 8 and 6 of Red Interface connector P1 are Special Function inputs #1 and #2 respectively. These inputs require an AC+ input to disable the Red Failure monitoring function during preemption. An active signal on **either** input will disable Red Failure monitoring. The RED FAIL indicator will then flash once every two seconds to indicate that Red Failure monitoring is disabled.

Option Switch #3 of SW-3 labeled "POLARITY" may be used to change the polarity of the Special Function inputs. When the switch is in the OFF position, the Special Function inputs will be active when AC+ is present. AC+ present on **either** input will disable Red Failure monitoring. An unused preemption input may be left OPEN (no connection) if the polarity switch is in the OFF position. When the switch is in the ON position, the Special Function inputs will be active when AC+ is NOT present. Lack of AC+ on **either** input will disable Red Failure monitoring. See Figure 4-1.

Polarity	SF #1	SF #2	Red Failure Monitoring
off	off	off	enabled
off	off	on	disabled - Preempt
off	on	off	disabled - Preempt
off	on	on	disabled - Preempt
on	off	off	disabled - Preempt
on	off	on	disabled - Preempt
on	on	off	disabled - Preempt
on	on	on	enabled

Figure 4-1

4.2 SSM Switch Programming

The SSM dip switches are located near the program card edge connector. The switch positions are labeled CH1 to CH16 on the PCB legend screen, corresponding to channels 1 through 16, respectively. To enable GYR-Dual Indication **and** Sequence Monitoring on a channel, place the corresponding channel dip switch to the ON position. Disabling Yellow input sensing on the program card will also disable GY-Dual Indication, GYR-Dual Indication and Sequence Monitoring for that channel regardless of the dip switch position for that channel. **The corresponding channel SSM dip switch must be placed in the OFF position when an unused Red field output terminal on the adapter PCB is connected to AC+.**

4.3 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 210E 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.

4.4 Option Switch Programming

The 210E series SIGNAL MONITOR provides five options to modify the monitor operation. The option switches are labeled SW-3 and are located near the WD ENABLE toggle switch.

4.4.1 BND Disable Switch

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

4.4.2 GY Enable Switch

Switch #2 of SW-3 is labeled "GY ENABLE". When this switch is in the ON position, all channels will be monitored for a simultaneous active Green and Yellow input regardless of the Red Enable input. This function is used to provide Dual Indication monitoring for channels which have the Red input tied to AC+, such as a five section head, or cabinet assemblies which are not adapted for Red Monitoring. See Section 2.4.

4.4.3 Polarity Switch

Switch #3 of SW-3 is labeled "POLARITY". When this switch is in the OFF position, the active state of the two Special Function inputs is when AC+ is present. When this switch is in the ON position, the active state of the two Special Function inputs are inverted (i.e. AC+ present is **NOT** active). See Figure 4-1 for Special Function operation.

4.4.4 Sequence Timing Switches

Switches #4,5,6 of SW-3 are labeled "YEL TIME 1", "YEL TIME 2", and "YEL TIME 3". These switches modify the minimum Yellow Clearance time used by the Sequence Monitoring function. Each binary weighted switch position adds 0.2 seconds to the minimum Yellow Clearance time. Figure 4-2 shows the possible programming positions.

YEL TIME 3	YEL TIME 2	YEL TIME 1	Minimum Yellow Timing
off	off	off	2.7 seconds
off	off	on	2.9 seconds
off	on	off	3.1 seconds
off	on	on	3.3 seconds
on	off	off	3.5 seconds
on	off	on	3.7 seconds
on	on	off	3.9 seconds
on	on	on	4.1 seconds

Figure 4-2

4.5 Watchdog Programming

4.5.1 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.

4.5.2 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.

4.6 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 2.9.

Section 5
FRONT PANEL DESCRIPTION

5.1 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 2.17.

(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.

(R) 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. If the unit is in the Diagnostic Display mode, the (R) WDT ERROR indicator will flash ON once per second to indicate the Channel Status display is showing Red channel status.

CONFLICT Indicator

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

RED FAIL Indicator

The RED FAIL indicator will illuminate when an absence of signal is detected on a channel(s). If the Red Enable input is not active, or a Special Function input is active, or the EE input (MC Coil) is active the RED FAIL indicator will flash once every two seconds to indicate that Extended Monitoring functions are disabled.

DUAL IND Indicator

The DUAL IND indicator will illuminate when a GY-Dual or GYR-Dual Indication fault is detected on a channel(s).

SEQUENCE Indicator

The SEQUENCE indicator will illuminate when the minimum Yellow Clearance time has not been met on a channel(s).

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 Red Failure, Dual Indication, Sequence, or 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.

5.2 Front Panel Controls

RESET Button

Depressing the Reset button resets the 210E 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 2.17.

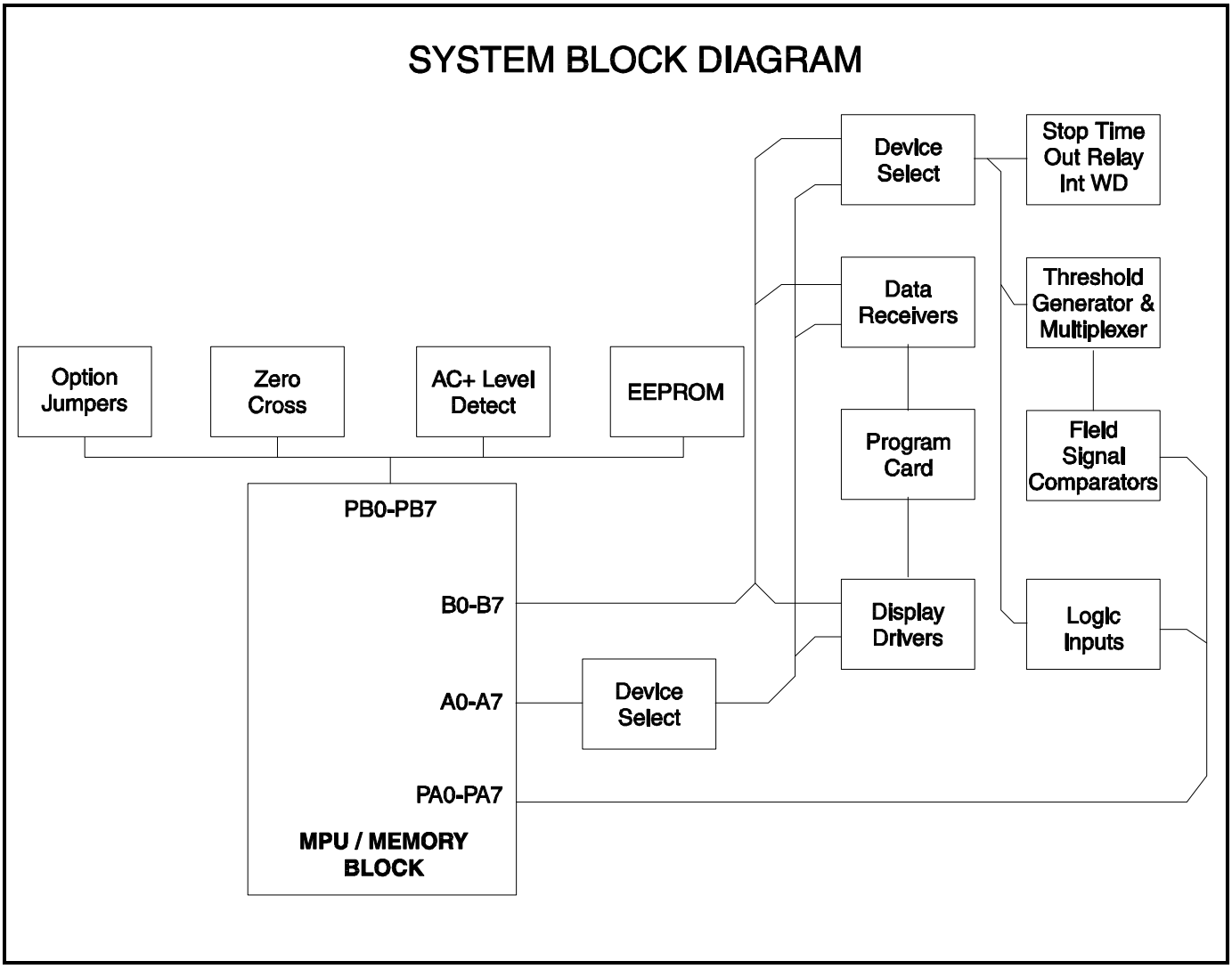
5.3 Red Interface Connector (P1)

This connector provides the required inputs for the 210E series SIGNAL MONITOR to monitor the Red Field Signal outputs. It is polarized to insure proper mating with the adapter cable. Ejector latches are included to facilitate removal and prevents the cable from inadvertently disconnecting. **The 210E series SIGNAL MONITOR will function as a standard 210 SIGNAL MONITOR when the cable is disconnected.**

Section 6
CIRCUIT OPERATION

6.1 Introduction

The 210E 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 210E 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.

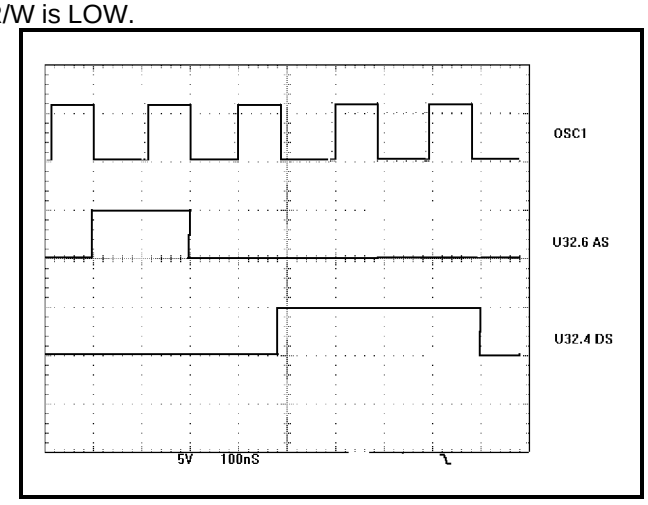


6.2 MPU Logic Operation

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

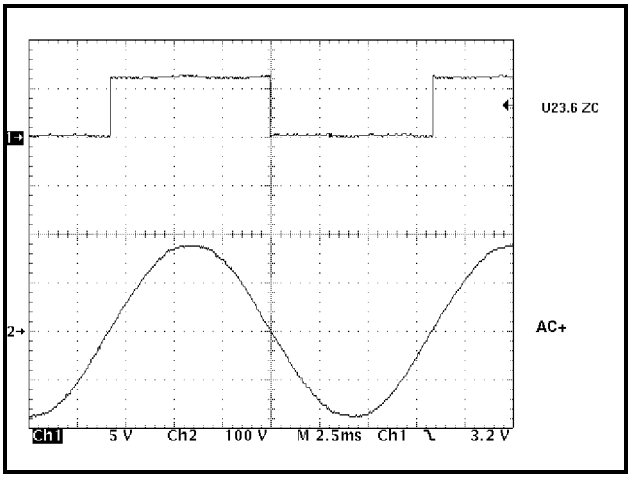
to control the direction of the data transfer on the data bus B0-B7. Data is written from the microprocessor to the peripheral device when R/W is LOW.



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.

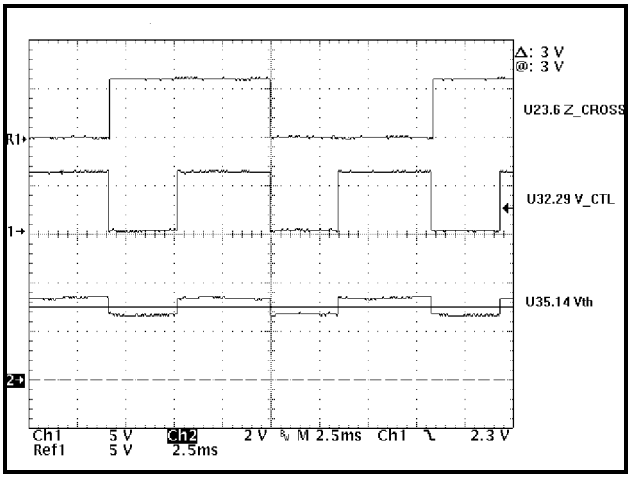
6.3 Zero-Cross Detection

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.



6.4 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.



6.5 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.

6.6 AC Field Input Signal Detection

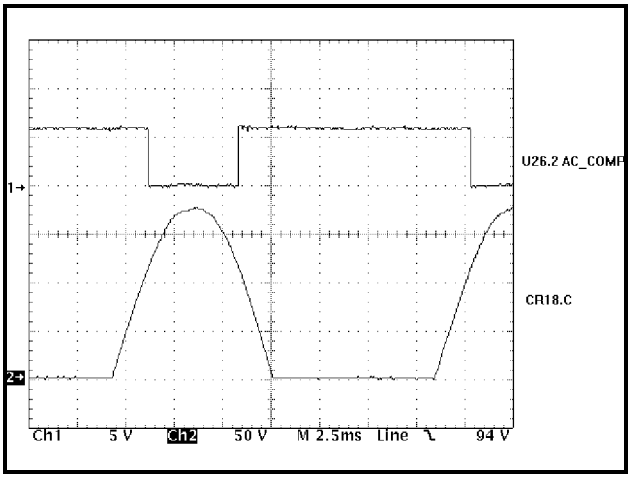
All AC field signals (Green, Yellow and Red) are voltage divided down and biased to a 3.0 Vdc reference allowing both halves of the sine wave to be sampled and tested. These signals are connected to the non-inverting inputs of the AC field input signal comparators. When the comparators are enabled by 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.

6.7 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.

6.8 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.



6.9 Non-volatile Memory

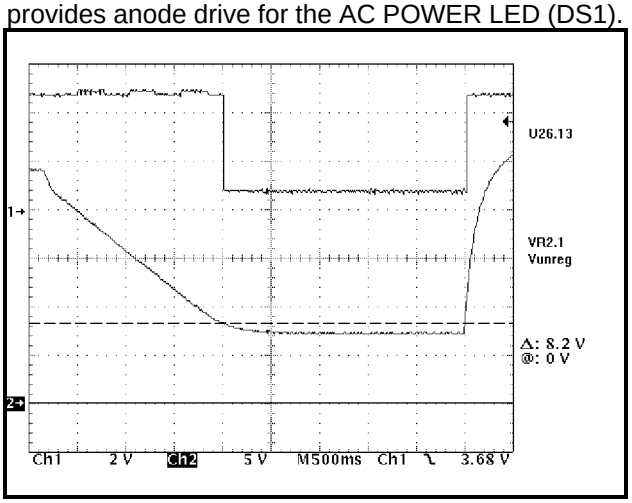
The EEPROM U38 is used to store fault status and display indications when a fault is detected. In the event of an AC Line power failure the fault and display status is recalled from the EEPROM when AC Line power is restored to the monitor. The EEPROM is clocked and enabled by latch U40 pins 15 and 6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

6.10 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.

6.11 Internal DC Supply Monitor

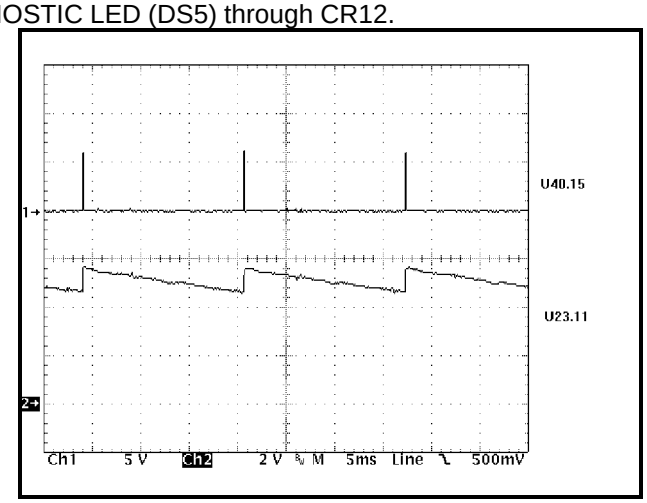
This circuit holds the MPU in reset if the internal unregulated supply is not above the required operating levels. The op-amp U26D is used as a non-inverting voltage comparator. The inverting input U26.10 is connected to the 2.5 Vdc reference VR1. Resistors R50 and U46.9 voltage divide the unregulated 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).



6.12 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.



6.13 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.

6.14 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).

6.15 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.

6.16 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 7
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 2.12.
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 6.3 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 6.12 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 8
SPECIFICATIONS

8.1 Electrical

8.1.1 Power Requirements

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

8.1.2 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*
Red Signal Inputs	(no detect)	less than 50 Vrms
	(detect)	greater than 70 Vrms
Red Enable Input	(no detect)	less than 50 Vrms
	(detect)	greater than 70 Vrms
Special Function Inputs	(no detect)	less than 50 Vrms
	(detect)	greater than 70 Vrms
Watchdog Enable (AC level)	(enable)	greater than 103 ±2 Vrms
	(disable)	less than 98 ±2 Vrms
AC Line Brown-out	(drop-out)	92 ±2 Vrms
AC Line Brown-out	(restore)	98 ±2 Vrms

8.1.3 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.

8.2 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
Red Fail	(no fault)	less than 700 milliseconds
	(fault)	greater than 1000 milliseconds
	(typical)	800 milliseconds
Dual Indication	(no fault)	less than 200 milliseconds
	(fault)	greater than 500 milliseconds
	(typical)	400 milliseconds
Sequence (minimum)	(no fault)	greater than 2.8 seconds
	(fault)	less than 2.6 seconds
Brown-out	(drop-out)	83 $\pm$17 milliseconds
Brown-out	(restore)	83 $\pm$17 milliseconds
Minimum flash after drop-out		4.25 seconds
Watchdog	(disable)	83 $\pm$17 milliseconds
Watchdog	(enable)	83 $\pm$17 milliseconds

8.3 Mechanical

Height	9.3 inches
Width	1.38 inches
Depth	10.17 inches

8.4 Environmental

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

Section 9
WIRING ASSIGNMENTS

9.1 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 (MC Coil)
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)

9.2 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.

9.3 Red Interface Connector (P1)

PIN	FUNCTION
1	CHANNEL 15 RED
2	CHANNEL 16 RED
3	CHANNEL 14 RED
4	CHASSIS GROUND (see note)
5	CHANNEL 13 RED
6	SPECIAL FUNCTION #2
7	CHANNEL 12 RED
8	SPECIAL FUNCTION #1
9	CHANNEL 10 RED
10	CHANNEL 11 RED
11	CHANNEL 9 RED
12	CHANNEL 8 RED
13	CHANNEL 7 RED
14	CHANNEL 6 RED
15	CHANNEL 5 RED
16	CHANNEL 4 RED
17	CHANNEL 3 RED
18	CHANNEL 2 RED
19	CHANNEL 1 RED
20	RED ENABLE

Note: Pin #4 may be used to connect the monitor chassis to the cabinet EARTH GROUND. To complete this connection, a soldered wire jumper must be placed in location E1. Monitor CHASSIS GROUND is also connected through the edge connector P2. The additional connection through the Red Interface cable can provide the CHASSIS GROUND connection to the monitor if the unit is removed from the cabinet with the Red Interface cable attached. The cabinet assembly must also be wired to connect the other end of the Red Interface cable to EARTH GROUND.

- WARNING -
IF JUMPER E1 IS USED BE SURE THAT ANY CABINET WIRING OR MONITOR TEST EQUIPMENT DOES NOT DRIVE PIN #4 WITH AN ACTIVE SIGNAL. USE OF THIS CHASSIS GROUND CONNECTION MAY MAKE THE UNIT INCOMPATIBLE WITH SOME SIGNAL MONITOR TESTERS.

THE P1 RED INTERFACE CONNECTOR SHOULD ALWAYS BE UNPLUGGED BEFORE REMOVING THE UNIT FROM THE CABINET TO PREVENT POTENTIAL EXPOSURE TO ELECTRICAL SHOCK.

9.4 RS-232 Connector (J1)

PIN	FUNCTION	I/O
1	NC	
2	TX DATA	O
3	RX DATA	I
4	DTR	I
5	SIGNAL GND	
6	NC	
7	NC	
8	NC	
9	NC	

The Data Terminal Ready (DTR) input must be in the high state (>4 Vdc) for the monitor RS-232 port to be active.

9.4.1 RS-232 Cable to a PC

A typical cable assembly for a DB-9 connector on the PC would be as follows:

PC DB-9		Monitor DB-9
RX pin 2	connect to	TX pin 2
TX pin 3	connect to	RX pin 3
DTR pin 4	connect to	DTR pin 4
GND pin 5	connect to	GND pin 5

For some computers, DTR pin 4 should also be connected to DSR pin 6 and CTS pin 8 on the PC DB-9 connector. Alternatively, jumpers E15 and E16 on the unit can be used to provide this handshake wrap around if required. A standard cable may then be used.

A typical cable assembly for a DB-25 connector on the PC would be as follows:

PC DB-25		Monitor DB-9
RX pin 3	connect to	TX pin 2
TX pin 2	connect to	RX pin 3
DTR pin 20	connect to	DTR pin 4
GND pin 7	connect to	GND pin 5

For some computers, DTR pin 4 should also be connected to DSR pin 6 and CTS pin 5 on the PC DB-25 connector.

9.4.2 RS-232 Cable to a 170 Controller Unit

A typical cable assembly for 170 CU connector would be as follows:

170		Monitor DB-9
RX pin L	connect to	TX pin 2
TX pin K	connect to	RX pin 3
+5 pin D	connect to	DTR pin 4
GND pin N	connect to	GND pin 5

DCD pin H should also be connected to +5 pin D and CTS pin M connected to RTS pin J on the Controller Unit connector.