OPERATIONS MANUAL

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MODEL 210 SERIES
RMS SIGNAL MONITOR

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

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

REV: July 2003

Powered by RMS-ENGINE™

Serial Number _____

Revision _____

CALTRANS

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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.

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Section 1
GENERAL DESCRIPTION

1.1 Introduction

The 210 series Signal Monitor consists of two models; the 210 and 210C. These units are built on the same platform with differences comprising hardware and software features. The model 210 is the base Caltrans QPL unit. Where not specified otherwise, the information in this manual will apply to all models. Text applying only to a specific model will be noted as such.

1.2 Basic Functions

The 210 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 210 series Signal Monitor also provides error sensing of the cabinet 24VDC supply and monitors the controller Watchdog output. The 210 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 *Caltrans Traffic Signal Control Equipment Specifications* (January 1989).

When triggered by the detection of a fault condition which exists longer than the minimum period, the 210 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 210 series Signal Monitor will then display the appropriate fault indications. The 210 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 Diagnostic Fail. In the event of AC Line power loss the 210 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 210 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 210 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 *Caltrans Traffic Signal Control Equipment Specifications*. When the 24VDC input falls below the specified voltage levels the 210 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 (WDT Error)

Sensing of the controller Watchdog output is provided as specified in Section 4.3 of the *Caltrans Traffic Signal Control Equipment Specifications*. When a logic transition is not sensed for the specified period (see Section 3.4.2) the 210 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 WDT Latch option (see section 3.3.1) determines whether this WDT Error fault mode is latched through an AC Line brownout or not. If the WDT Latch option is not selected, an AC Line brownout condition will reset the WDT ERROR fault mode when the AC Line is restored. The WDT Error indicator will remain illuminated until a Reset command is issued via the front panel RESET button or External Reset input. This indicates to the technician that a WDT Error occurred but was cleared by an AC Line brownout.

If the WDT LATCH option is selected, the WDT Error fault mode is maintained until a Reset command is applied.

Section 2
GENERAL CHARACTERISTICS

The following extended features are provided on the 210 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 210 series Signal Monitor is a dual 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 210 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.

Input voltages are measured using a true Root Mean Squared (RMS) technique. A dedicated microprocessor RMS-Engine controls the analog to digital (A/D) hardware which samples each AC input voltage 32 times per cycle. The RMS-Engine then calculates the true RMS voltage value producing accurate results which are very insensitive to changes in frequency, phase, wave shape, and distortion. 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 210 series Signal Monitor will suspend all fault monitoring functions, close the Output relay contacts, and enable the Stop-Time output to the controller. 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.

2.2.1 Minimum Flash Time

A Minimum Flash time option can be selected (see section 3.3.2) which provides a flash interval of at least 6 seconds and at most 10 seconds in duration following a power-up, an AC Line interruption, or a brownout restore. During this interval the unit will suspend all fault monitoring functions and close the Output relay contacts. The AC indicator on the front panel will flash at a rate of 4Hz.

The minimum flash interval will be terminated after at least 6 seconds if the Watchdog input has made 5 transitions between the True and False state and the AC Line voltage is greater than the restore level.

2.3 Recurrent Pulse (RP) Detection

This error detection function supplements the normal Conflict monitoring algorithm for sensing faults which are intermittent or pulsing in nature. The RMS-Engine is designed to filter out short term transients commonly found on the electrical service and provide noise immunity against false signal detections. The Recurrent Pulse detection function is designed to respond to fault conditions which are intermittent in nature and do not meet the continuous timing requirements of the normal detection algorithms, yet may still produce improper signal displays. These input conditions are differentiated by their longer time constant and fault response times.

Figure 2-1 shows an example of a recurrent Conflict fault. Channel 2 Green is detected active due to a malfunction of the load switch which caused the output to “flicker” On for 100 ms approximately every 200 ms. Since normal Conflict

detection requires a continuous fault of at least 350 ms typical, this event could go undetected. The Recurrent Pulse detection algorithm will combine these pulses into one event and trigger a Conflict fault once the longer recurrent timing threshold is exceeded.

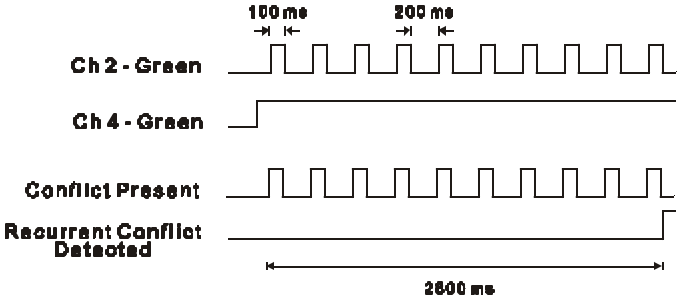


Figure 2-1

When triggered by a recurrent fault condition, the 210 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 CONFLICT indicator along with the RP DETECT indicator. The unit will remain in the fault mode until reset by the Reset button or the External Reset input. Fault response times will vary depending on the pulse width and frequency of the recurrent inputs, but will range from 1000 ms minimum to 10.4 seconds maximum. Recurrent Pulse detection can be disabled with the RP DISABLE option switch (SW3-2), see Section 3.2.1.

2.4 Non-Volatile Fault Memory

The 210 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.

2.5 PCA (Program Card Absent) Indication

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

2.6 Configuration Change Monitoring

The 210 series Signal Monitor maintains an internally calculated CRC value of the current configuration settings. These settings include the permissive diode matrix, Yellow Disable switches, Option switches, SEL1 through SEL10 jumpers, and the Watchdog Enable switch. On power-up, reset, and periodically during operation, the unit will compare the current configuration settings with the previously stored value. If the settings have changed, the 210 series Signal Monitor will automatically log the new setting.

When the Configuration Change Fault select option is jumpered (see section 3.3.3), any change in the configuration parameters will cause the 210 series Signal Monitor to enter the fault mode causing the Output relay contacts to close and enabling the Stop-Time output to the controller. To indicate this fault mode the PCA indicator will flash at a 4 Hz rate. Depressing the Reset button for 5 full seconds will clear this fault and log the new configuration parameters.

If the Configuration Change Fault select jumper is not installed, the unit will not set the fault mode but will still log the configuration change.

2.7 Internal MPU Watchdog

The 210 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 325 milliseconds, the 210 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 E5 may be inserted. With latching operation, only a loss of AC Line will restore operation. See Section 3.5.

2.8 Reset Input Detection

A reset command from either the front panel Reset button or External Reset input will cause a one-time reset command to the monitor. If the reset command is maintained longer than 500 milliseconds, the monitor will resume monitoring functions and the Reset command will then provide input to the Diagnostic Display mode (see Section 2.12).

2.9 LED Test

The monitor will illuminate all front panel indicators for 500 milliseconds when a Reset command is issued by the front panel Reset button or External Reset Input. This function provides a means to verify the operation of all front panel indicators.

2.10 Memory Test

The 210 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 210 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. 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.

2.11 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 210 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.

2.12 210 Diagnostic Display Mode

The 210 series Signal Monitor provides two means of displaying the individual Green and Yellow 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.

2.12.1 210 No Fault Diagnostic Display

When the 210 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)	

2.12.2 210 Fault Diagnostic Display

Once the 210 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 210 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 210 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 seated.

3.2 Option Jumper Programming

The 210 series Signal Monitor provides jumper options to modify the monitor operation. The Option jumpers are labeled OPTIONS (SW3) and are located near the program card edge connector. Option jumpers SW3-1, SW3-4 through SW3-8 are not used.

3.2.1 Recurrent Pulse (RP) Disable Jumper (RP DISABLE)

Jumper #2 of SW3 is labeled "RP DISABLE". When this jumper is in position, the Recurrent Pulse detection mode is disabled. See Section 2.3.

3.2.2 WDT Timing Jumper

Jumper #3 of SW3 is labeled "WD 1.0 SEC". When this jumper is in position, the Watchdog fault time is set to 1.0 $\pm$0.1 seconds. When this jumper is not in position, the Watchdog fault time is set to 1.5 $\pm$0.1 seconds.

3.3 Select Jumper Programming

The 210 series Signal Monitor also provides jumper options to modify the monitor operation. The Select jumpers are labeled SEL1 through SEL10. SEL6 through SEL10 are reserved for EDI configuration programming and should not be modified except by the factory.

3.3.1 Watchdog Latch Select (SEL1)

The WDT Latch select determines whether the WDT Error fault mode is latched through an AC Line brownout or not. If the WDT Latch select is not jumpered, an AC Line brownout condition will reset the WDT ERROR fault mode when the AC Line is restored. The WDT Error indicator will remain illuminated until a Reset command is issued via the front panel RESET button or External Reset input. See section 1.2.3.

If the WDT LATCH select is jumpered, the WDT Error fault mode is maintained until a Reset command is applied.

3.3.2 Minimum Flash Enable Select (SEL2)

When jumpered, the Minimum Flash function provides a flash interval of at least 6 seconds and at most 10 seconds in duration following a power-up, an AC Line interruption, or a brownout restore. See section 2.2.1.

3.3.3 Configuration Change Fault Select (SEL3)

When jumpered, the Configuration Change Fault function will be enabled causing the 210 series Signal Monitor to enter the fault mode if any configuration parameter is changed. If the Configuration Change Fault Select jumper is not installed, the unit will not set the fault mode. See section 2.6.

3.3.4 AC Line Brown-out Select (SEL5)

When jumpered, the AC Line Brown-out levels will be set for the 2010 series with “dropout” at 98 $\pm$2 Vrms and “restore” at 103 $\pm$2 Vrms with timing at 400 $\pm$50 ms. When not jumpered, the AC Line Brown-out levels will be set for the 210C series with “dropout” at 82 $\pm$2 Vrms and “restore” at 87 $\pm$2 Vrms with timing at 80 $\pm$17 ms. See section 2.2.

3.4 Watchdog Programming

3.4.1 Watchdog Enable Switch

The toggle switch SW2 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.

3.4.2 Watchdog Timing Option

Switch #3 of the OPTIONS switch (SW3) is labeled "WD 1.0 SEC". When this switch is in the ON position, the Watchdog fault time is set to 1.0 $\pm$0.1 seconds. When this switch is in the OFF position, the Watchdog fault time is set to 1.5 $\pm$0.1 seconds.

3.5 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 "E5". See Section 2.7.

Section 4
FRONT PANEL DESCRIPTION

4.1 Indicators

(G) AC POWER Indicator

The AC POWER indicator will illuminate when the AC Line voltage level is above the brown-out "restore" level. The indicator 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 less than 75 ±2 Vac. During the minimum flash interval the indicator will flash at a rate of 4Hz. See Section 2.2.

If the unit is in the 210 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 210 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. See Section 2.12.

WDT ERROR Indicator

The WDT ERROR indicator will illuminate when a controller Watchdog fault is detected. If the WD ENABLE switch 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.

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.

If the unit is in the Configuration Change Fault mode, the PCA indicator will flash at a 4 Hz rate (see section 2.6).

RP DETECT Indicator

The RP DETECT indicator will illuminate when the Recurrent Pulse detection function has triggered a Conflict fault. See Section 2.3.

DIAGNOSTIC Indicator

The DIAGNOSTIC indicator will illuminate when an internal hardware or firmware test function has failed. 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.

210 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 Conflict, 24VDC fault (VDC FAILED), or Watchdog fault (WDT ERROR).

4.2 Front Panel Controls

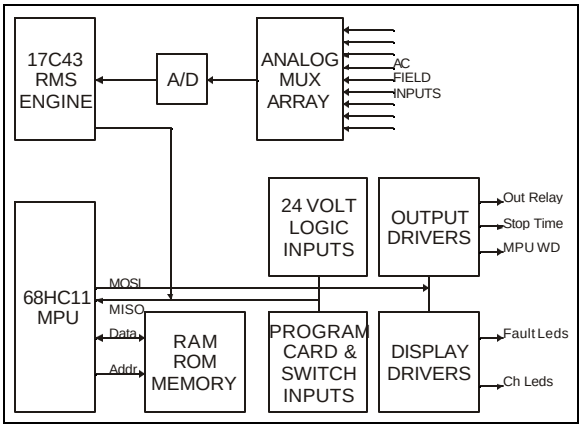
RESET Button

Depressing the Reset button resets the 210 series Signal Monitor after it has been triggered by a fault. 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
THEORY OF OPERATION

5.1 System Description

The 210 series Signal Monitor uses a dual microprocessor architecture consisting of an MC68HC11D0 main microprocessor unit (MPU) and a Microchip PIC17C43 based RMS-Engine. The RMS-Engine is a dedicated single-chip high speed micro-controller used to sample the AC field inputs and calculate the true Root Mean Squared (RMS) voltage. This true RMS voltage information is then transmitted to the main microprocessor for fault processing.



The MC68HC11D0 main microprocessor uses a high speed synchronous serial I/O system called the Serial Peripheral Interface (SPI) to exchange data with the peripheral circuit blocks. It controls all functions of the unit except for those of the RMS-Engine.

5.2 Detailed Description of Circuit Operation

5.2.1 Main MPU Logic

The MC68HC11D0 main microprocessor (U8) operates in the Expanded Multiplexed mode which allows for external memory devices. The program firmware is contained in the 29F010B Flash memory device (U12) and program data storage is contained in the SRM2264 8Kx8 static RAM (U18). The expanded address and data buss is used to link the memory devices with the microprocessor. A 74HC137 (U21) selector also resides on the buss to generate chip select signals for the SPI devices.

5.2.2 Serial Peripheral Interface (SPI)

The Serial Peripheral Interface (SPI) is a high speed synchronous serial I/O system used to interconnect the main microprocessor to the following circuit blocks: EEprom (U20), 24Vdc Logic Inputs (U25), Display Multiplexer (U2,3), Program Card and Switch inputs (U36,37), and the RMS-Engine (U38).

Data is clocked out of the main microprocessor on the MOSI pin (U8.18) while data is clocked in on the MISO pin (U8.17). The SCLK signal (U8.19) provides the synchronous clock. A peripheral device must be selected by U21 before SPI transfers may take place.

5.2.3 Internal MPU Watchdog

Circuit U4A and U4B comprise the internal MPU Watchdog circuit. If this circuit does receive an input from the main microprocessor for at least 325 ms, the circuit will trigger and force the Output relay to the fault mode, enable the Stop-Time output, and illuminate the DIAGNOSTIC indicator. This indicates that the microprocessor has failed to operate its program loop. Under normal conditions the microprocessor will clock this circuit every 20 ms.

If jumper E5 is installed this fault mode will only be reset by a complete power down cycle.

5.2.4 EEprom Memory

The 25C320 Serial EEprom (U20) device provides 4096 bytes of nonvolatile memory. It is interfaced to the main microprocessor through the SPI port. No battery is required to maintain the data in this device.

5.2.5 24Vdc Logic Inputs

The Cabinet 24Vdc input, CU Watchdog input, and External Reset input are thresholded by comparator U47 to determine true/false input status. Opto-couplers U42-45 provide electrical isolation between Logic Ground and Neutral. The 74HC165 (U25) shift register uses the SPI port to transfer this data to the main microprocessor.

5.2.6 Display

The front panel LED display is multiplexed by the row driver U3 and the column driver U2. The scan rate is approximately 60 Hz. Display data is shifted into U3 while individual columns are selected by U2 using the SPI interface.

5.2.7 Program Card and Switch Inputs

The program card and configuration switch inputs are scanned through a diode matrix using row drivers U34 and U35. Column buffers U36 and U37 select the column to be read. These devices transfer data to the main MPU through the SPI interface.

5.2.8 RMS-Engine

The RMS-Engine is a Microchip PIC17C43-16I/P single-chip high performance RISC microcomputer executing proprietary firmware that calculates true RMS voltages for each input channel. The resulting data is transferred to the main MPU via the SPI interface. The analog to digital converter U39 provides the voltage measurement data for the RMS-Engine approximately every 6 microseconds. Analog multiplexers (74HC4051N) select the appropriate channel for sampling. Op amp circuits U46A, U46B, and U46C perform a full wave rectification circuit.

5.2.9 Power Supply

The switching power supply is based on a MIC38C43 (U22) fixed frequency current-mode PWM controller. The AC Line is full wave rectified and charges capacitor C72 to approximately 170 Vdc. The PWM controller switches current from C72 through the transformer T1 using transistor Q3 at approximately 200 KHz. The transformer couples this energy to the secondaries and provides the following output voltages: VDD=+5 Vdc, VCC=+8 Vdc, VGG=-8 Vdc, VEE=-5 Vdc, VCCL=+16 Vdc, and VDDS=+5 Vdc. Opto-coupler U24 provides feedback to the controller for regulation.

Section 6
MAINTENANCE

6.1 Preventive Maintenance

No adjustments or alignments are required. It is recommended that the signal monitor be tested at least annually to ensure compliance with the proper factory and agency specifications.

6.2 Trouble Shooting Sequence

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 C72 with an oscilloscope or volt meter. It should read approximately 170 Vdc when the AC Line is equal to or greater than 110 Vrms. If the regulated supply (VDD) is less than 4.5 Vdc the internal power supply monitoring circuit (U19) will hold the MPU in reset and the DIAGNOSTIC indicator on the front panel should illuminate. Measure the regulated voltage across capacitor C22. If it measures lower than 5 $\pm$0.5 Vdc 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 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 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 2.10.
D) Absence of internal watchdog pulses may be due to the following conditions: the MPU is not executing or completing the program loop or the hardware to detect the internal watchdog pulses is not functioning. Place an oscilloscope probe on U4.2. If there are no pulses, depress the front panel reset switch to re-start the MPU. If the watchdog pulses are now present on U4.2 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 verify all connections are good and the diode is working correctly.

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
AC Line Brown-out (2010)	(drop-out)	98 ±2 Vrms
AC Line Brown-out (2010)	(restore)	103 ±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

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 1100 milliseconds
	(typical)	1000 milliseconds
	(no fault)	less than 1400 milliseconds
	(fault)	greater than 1600 milliseconds
	(typical)	1500 milliseconds
Brown-out	(drop-out)	80 $\pm$17 milliseconds
Brown-out	(restore)	80 $\pm$17 milliseconds
Brown-out (2010)	(drop-out)	400 $\pm$50 milliseconds
Brown-out (2010)	(restore)	400 $\pm$50 milliseconds
Minimum flash after restore		6.0 $\pm$0.5 seconds
Maximum flash after restore		10.0 $\pm$0.5 seconds
Watchdog	(disable)	80 $\pm$17 milliseconds
Watchdog	(enable)	80 $\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 (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 edge-card 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 edge-card connector having 0.156" centers.