Model 222

Loop Detector

Version 6

State of California

Operations Manual

Inductive Loop Detector

This manual contains technical information for the **Model 222** Loop Detector

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THE FOLLOWING PRODUCT WAS DESIGNED, INSPECTED, TESTED AND MANUFACTURED IN THE USA BY EBERLE DESIGN, INC. IN PHOENIX, ARIZONA.

MAINTENANCE NOTE

IT IS AN EBERLE DESIGN, INC. RECOMMENDATION THAT EACH UNIT BE TESTED AT LEAST ANNUALLY TO ENSURE COMPLIANCE WITH FACTORY SPECIFICATIONS AND MEETS PROPER OPERATIONAL STANDARDS. THE RESULTS OF THIS TESTING WILL BE DOCUMENTED.

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Model 222 Operations Manual

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Section 1 Glossary

Wherever the following symbols, terms, or abbreviations are used, the intent and meaning shall be interpreted as follows:

+: Positive.

-: Negative.

°C: Degree Celcius.

°F: Degree Fahrenheit.

AC: Alternating Current.

CALL: The actuated output signal from the detector.

COMMON: The return path or negative side of a power source.

CROSSTALK: The mutual coupling of magnetic fields between adjacent loop/lead-in systems that produces interaction when operating at similar frequencies.

DC: Direct Current.

DIP: Dual In-line Package.

DELTA L (dL or ΔL): The change of inductance.

FAIL-SAFE: The detector channel maintains a CALL output during a loop failure condition.

FAIL-SECURE: The detector channel maintains a NO CALL output during a loop failure condition.

FREQUENCY: The number of times an alternating current repeats its cycle in one second.

GND: Ground.

HENRY (H or h): The unit of measurement of inductance.

HERTZ (Hz): The measure of frequency corresponding to one (1) cycle per second.

IC: Integrated Circuit.

INDUCTANCE: The resistance to change of current in a circuit.

LED: Light Emitting Diode.

mA: The abbreviation for milliAmp.

ms: The abbreviation for millisecond.

Q FACTOR: Loop Quality Factor. A measure of the resonant efficiency of the loop circuit.

The formula for Q is:

$$Q = \frac{2 \Pi f L_S}{R_S}$$

Where:

Q = Quality factor.
Π = 3.14159 (a constant).
f = Series inductance frequency, Hz.
L_S = Series inductance, henries.
R_S = Series resistance, ohms.

RESISTANCE: The opposition to the passage of an electric current.

SENSITIVITY: The minimum percent change of the total inductance required for the detector to actuate a CALL output.

SCANNING: Alternating the activation of each channel's loop circuit to eliminate crosstalk between adjacent loops connected to the same detector module.

VAC: Volts DC.

VDC: Volts AC.

Section 2 General Description

This Operation Manual was written for people installing, operating, and troubleshooting Reno A&E Model 222 inductive loop vehicle detectors. The Model 222 is a scanning, two channel, card rack type loop detector designed to meet or exceed the specifications for 170 and NEMA TS 1 type traffic control applications as specified in Caltrans Traffic Signal Control Equipment Specifications (TSCES) dated January 1989 (and Addendum 4 July 1991) and Caltrans Transportation Electrical Equipment Specifications (TEES) dated August 16, 2002.

The Model 222 detector uses a microcontroller to monitor and process signals from two separate loop/lead-in circuits. The operation of each channel is independently programmed with a front panel DIP switch module to provide the following selections:

- Eight (8) Sensitivity Levels -ΔL/L%.
- Presence or Pulse Mode.
- Fail-Safe or Fail-Secure in a Loop Fail Condition Default.
- Four (4) Frequency Selections.
- Channel Disable.

The FAIL-SAFE / FAIL-SECURE switch selects the channel output state as CALL or NO CALL during a loop failure condition. FAIL-SAFE selection, which is the standard for intersection control, generates a continuous CALL output state for as long as a loop failure condition exists. FAIL-SECURE selection generates a NO CALL output state during a loop failure condition. Traffic control applications such as incident detection are best suited to Fail-Secure operation, because a constant CALL from a failed loop appears as though the traffic movement has stopped. FAIL-SECURE selection also selects faster response times for very accurate speed measurement. The switch selection allows the user to set the detector operation for the application.

The Model 222 alternately excites the two loop circuits. This eliminates adjacent loop fields from coupling together (crosstalk) when the loops are connected to the same detector. Each time the loop circuit is activated, loop data is obtained and recorded. The data is compared to previous samples for the amount and rate of change. A slow rate of change, as is the case with environmental drift, is continuously tracked. If a rapid change exceeds a threshold set by the sensitivity level, the output is activated.

Each channel has a single, dual color (green / red) Detect / Fail LED indicator. The LED provides an indication of the channel's output state and loop failure conditions. Output state conditions are indicated when the Detect / Fail LED is illuminated in a green state. Loop failure conditions are indicated when the Detect / Fail LED is illuminated in a red state.

If the total inductance of the loop input network goes out of the range specified for the detector, or rapidly changes by more than ±25%, the channel will enter the programmed Fail-Safe or Fail-Secure mode of operation. The Detect / Fail LED will illuminate (red) to indicate that an Open Loop Failure or an inductance change condition of greater than +25% exists. The Detect / Fail LED will flash (red) at a one Hz rate to indicate a Shorted Loop Failure or an inductance change condition of greater than -25% exists. Either indication will continue as long as the loop failure exists. If the loop self-heals, the channel will resume operation in a normal manner, except the Detect / Fail LED will flash (red) at a rate of three 50 millisecond flashes per second, thus providing an alert that a loop fail condition has occurred. Any prior loop failure indication will continue until the detector is manually reset or power is removed.

In addition, the Reno A&E Model 222 has a Test Mode that thoroughly tests the detector module without the external test equipment. Test Mode uses the microcontroller to verify the proper operation of the LED indicators and DIP switches. Each channel's loop oscillator circuit can also be tested to verify the correct frequency range in each of the four frequency selections.

Section 3 General Characteristics

3.1 CHANNEL DISABLE

Each detector channel can be disabled by means of a front panel mounted DIP switch. When set to the *DISABLE* (ON) position, the channel output is continuously in the NO CALL state regardless of the presence or absence of vehicles over the loop. The loop oscillator is not activated when the channel is in the Disabled State. Changing this setting will RESET the channel.

3.2 LOOP FREQUENCY

Four loop frequency settings per channel (normally in the range of 20 to 100 kilohertz) are selectable by means of two front panel mounted DIP switches. The actual loop operating frequency is a function of the loop/lead-in network.

3.3 FAIL-SAFE / FAIL-SECURE OPERATION

Fail-Safe or Fail-Secure operation is selectable for each channel using a front panel mounted DIP switch. During a loop failure condition, the state of the channel's output can be selected as CALL in Fail-Safe Operation or NO CALL in Fail-Secure Operation. Fail-Safe operation during a loop failure is the standard operation for intersection control. Fail-Secure operation during a loop failure is typically used for incident detection systems for freeway management. Fail-Secure selection also selects fast response for very accurate speed measurements (see Response Times). Changing this setting will RESET the channel.

3.4 PRESENCE / PULSE

One of these two exclusive modes of operation for each channel is selected by means of a front panel mounted DIP switch:

Presence Mode: CALL hold time is four minutes minimum (regardless of vehicle size) and typically one to three hours for an automobile or truck.

NOTE: A minimum 100 millisecond presence output time can be selected by setting DIP switch 2 of the two position DIP switch module labeled SW1 located on the PC board to the ON position. When the switch is in the OFF position, the presence time reflects the actual time the vehicle is over the loop.

Pulse Mode: A pulse of 125 ±10 millisecond duration is generated for each vehicle entering the loop detection zone. Each detected vehicle is instantly tuned out if it remains in the loop detection zone longer than two seconds. This enables detection of subsequent vehicles entering the loop detection zone. After each vehicle leaves the loop detection zone, the channel resumes full sensitivity within one second.

Changing the Presence / Pulse Mode switch will RESET the channel.

3.5 AUDIBLE DETECT SIGNAL (BUZZER)

The pushbutton on the front panel labeled BUZZER is used to enable an Audible Detect Signal. When this feature is enabled (ON), an audible signal will be activated whenever the detection zone for the selected channel is occupied. The audible signal indicates actual occupancy of the loop detection zone. This feature allows a technician to watch the detection zone on the street and confirm correct detector operation without having to look at the detector front panel LEDs as well.

3.6 TEST MODE

Test Mode uses the microcontroller to verify the proper operation of the detector's controls and indicators (switches and LEDs). Each channel's loop oscillator circuit is also tested to verify the correct frequency range in each of the four frequency selections.

Section 4 Specifications

4.1 PHYSICAL

WEIGHT: 6.0 oz (170 gm).

SIZE: 4.500 inches (11.43 cm) high x 1.120 inches (2.84 cm) wide x 6.875 inches (17.46 cm) long including connector (not including front handle). Handle adds 1.00 inch (2.54 cm) to depth measurement.

OPERATING TEMPERATURE: -40° F to +180° F (-40° C to +82° C).

CIRCUIT BOARD: Printed circuit boards are 0.062 inch thick FR4 material with 2 oz. copper on both sides and plated through holes. Circuit board and components are conformal coated with polyurethane.

CONNECTOR: 2 x 22 contact edge card connector with 0.156 inch (0.396 cm) contact centers. Key slots located between B/2 & C/3, M/11 & N/12, and E/5 & F/6. See Section 4.5 for pin assignments.

4.2 ELECTRICAL

POWER: 10.8 to 30 VDC. 100 milliamps maximum.

LOOP INDUCTANCE RANGE: 20 to 2000 microhenries with a Q factor of 5 or greater.

LOOP INPUTS: Transformer isolated. The minimum capacitance added by the detector is 0.068 microfarad.

LIGHTNING PROTECTION: The detector can tolerate, without damage, a 10 microfarad capacitor charged to 2,000 volts being discharged directly into the loop input terminals, or a 10 microfarad capacitor charged to 2,000 volts being discharged between either loop terminal and earth ground.

DETECTOR RESET: Each detector channel can be manually reset by momentarily changing any switch position (except the Frequency switch). The detector can also be reset by connecting a logic ground signal to pin C of the card edge connector or the return of power after a power loss.

SOLID STATE OUTPUT RATING: Optically isolated. 30 VDC max. collector (drain) to emitter (source). 50 mA max. saturation current. 2 VDC max. transistor saturation voltage. The output is protected with a 33-volt Zener diode connected between the collector (drain) and emitter (source).

SCANNING OPERATION: The loop(s) connected to each detector channel are activated alternately to minimize crosstalk between adjacent loops connected to the same detector module.

4.3 OPERATIONAL

DETECT / FAIL INDICATORS: The detector has one super bright, high intensity, two color (green / red) light emitting diode (LED) per channel to indicate a CALL output and/or the status of any current or prior loop failure conditions. A continuous ON (green) state indicates a CALL output. A continuous ON (red) state indicates that a current open loop failure condition or an inductance change condition of greater than +25% exists. This indication also generates a CALL output if the channel is set to operate in Fail-Safe Mode. If set to operate in Fail-Secure Mode, a CALL output is not generated. A one Hz (red) flash rate indicates that a current shorted loop failure condition or an inductance change condition of greater than -25% exists. This indication also generates a CALL output if the channel is set to operate in Fail-Safe Mode. If set to operate in Fail-Secure Mode, a CALL output is not generated. A flash rate of three 50 millisecond (red) pulses indicates a prior loop failure condition. A flash rate of three 50 millisecond (red) pulses followed by a single 750 millisecond (green) pulse indicates a prior loop failure condition and a current CALL output (detect state). If either channel has the audible detect feature activated, that channel's Detect / Fail LED will be illuminated in an orange state for any CALL output condition.

RESPONSE TIME: Response times depend on the Fail-Safe / Fail-Secure selection and the Sensitivity Level settings. See ***Table: Sensitivity, -ΔL/L, and Response Times***, for actual response times.

SELF-TUNING: The detector automatically tunes and is operational within two seconds after application of power or after being reset. Full sensitivity and hold time requires 30 seconds of operation.

ENVIRONMENTAL AND TRACKING: The detector is fully self-compensating for environmental changes and loop drift over the full temperature range and the entire loop inductance range.

GROUNDED LOOP OPERATION: The loop isolation transformer allows operation with poor quality loops (which may include one short to ground at a single point).

LOOP FEEDER LENGTH: Up to 5000 feet (1500m.) maximum with proper feeder cable and appropriate loops.

LOOP (FAIL) MONITOR: If the total inductance of the channel's loop input network goes out of the range specified for the detector, or rapidly changes by more than ±25%, the channel will immediately enter the programmed Fail-Safe or Fail-Secure mode of operation. The Fail-Safe mode of operation generates a continuous CALL during the loop failure. The Fail-Secure mode of operation does not

generate a continuous CALL during the loop failure. The Detect / Fail LED will provide an indication to identify the type of loop failure condition that exists. A continuous ON (red) state indicates that a current open loop failure condition or an inductance change condition of greater than +25% exists. A one Hz (red) flash rate indicates that a current shorted loop failure condition or an inductance change condition of greater than -25% exists. This will continue as long as the loop fault exists. ***However, if the detector is reset, or power is momentarily lost, the detector will retune if the loop inductance is within the acceptable range. If any type of loop failure occurs in one (or more) loop(s) in a group of two or more loops wired in parallel, the detector will not respond with a Fail-Safe output following any type of reset. It is essential that multiple loops wired to a common detector channel always be wired in series to ensure Fail-Safe operation under all circumstances.*** If the loop self-heals, the detector will resume operation in a normal manner except that the Detect / Fail LED will begin to flash at a rate of three 50 millisecond (red) flashes per second, thus providing an alert that the detector has experienced a prior loop failure condition. During this state, the Detect / Fail LED will also illuminate for 750 milliseconds (green) for a CALL output. The Detect / Fail LED will continue this display pattern indicating the prior loop failure condition and/or detect state until the detector is manually reset or power is removed.

4.4 TABLE: SENSITIVITY, -ΔL/L, AND RESPONSE TIMES

Sensitivity Level	-ΔL/L Threshold	Response Time (Fail-Secure Mode)	Response Time (Fail-Safe Mode)
0	1.28%	3.5 ±2.5 ms	65 ±25 ms
1	0.64%	3.5 ±2.5 ms	65 ±25 ms
2	0.32%	3.5 ±2.5 ms	65 ±25 ms
3	0.16%	3.5 ±2.5 ms	65 ±25 ms
4	0.08%	4.5 ±3.5 ms	65 ±25 ms
5	0.04%	7 ±6 ms	65 ±25 ms
6	0.02%	11.5 ±10.5 ms	65 ±25 ms
7	0.01%	21.5 ±20.5 ms	65 ±25 ms

NOTE: To achieve the response times listed, the Sensitivity and Fail-Safe / Fail Secure selections for both channels must be the same.
Changing the sensitivity setting will RESET the channel.

4.5 TABLE: DEFAULT SETTINGS

FRONT PANEL MOUNTED DIP SWITCHES

DIP Switch	Function	Setting	Position
1	Disable	Off	OFF
2	Frequency	0	OFF
3			OFF
4	Fail-Safe / Fail-Secure	Fail-Safe	ON
5	Presence / Pulse Mode	Presence	ON
6	Sensitivity	6	OFF
7			ON
8			ON

NOTE: Settings shown apply to both channels.

PC BOARD MOUNTED DIP SWITCHES

DIP Switch	Function	Setting	Position
1	Test Mode	Off	OFF
2	100 ms Minimum Output	Off	OFF

4.6 TABLE: PIN ASSIGNMENTS

Pin	Function
A	DC Common
B	DC +
C	Reset Input
D/4	Channel 1 Loop Input
E/5	Channel 1 Loop Input
F	Channel 1 Output, Collector (Drain)
H	Channel 1 Output, Emitter (Source)
J/8	Channel 2 Loop Input
K/9	Channel 2 Loop Input
L	Chassis Ground
W	Channel 2 Output, Collector (Drain)
X	Channel 2 Output, Emitter (Source)
NOTE: Pins not listed above are spares.	

SENSITIVITY LEVEL - CHANNEL 1
- 0 = Lowest
- 8 = Highest

FAIL-SAFE / SECURE - CHANNEL 1
- OFF = Fail-Secure Mode
- ON = Fail-Safe Mode

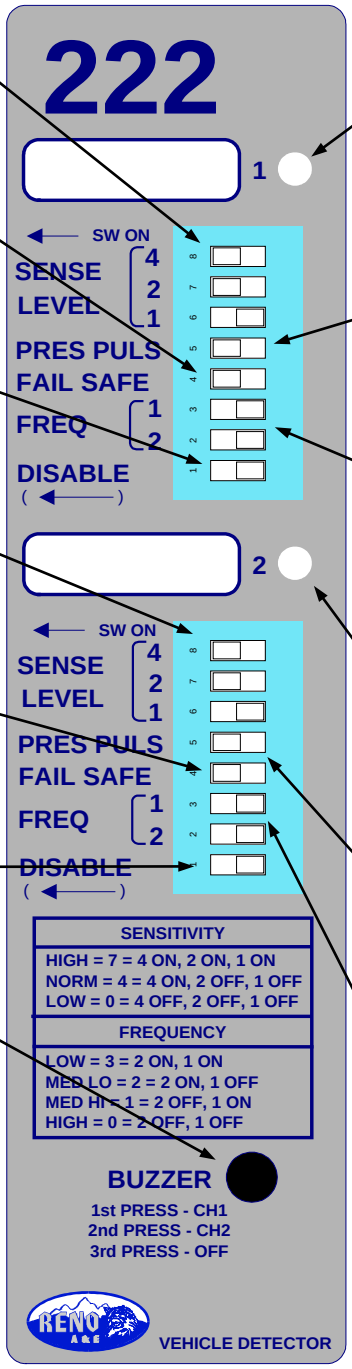
CHANNEL DISABLE - CHANNEL 1
- ON = Disabled
- OFF = Enabled

SENSITIVITY LEVEL - CHANNEL 2
- 0 = Lowest
- 8 = Highest

FAIL-SAFE / SECURE - CHANNEL 2
- OFF = Fail-Secure Mode
- ON = Fail-Safe Mode

CHANNEL DISABLE - CHANNEL 2
- ON = Disabled
- OFF = Enabled

BUZZER PUSHBUTTON
Press to Activate / Deactivate Audible Detect Signal



DETECT / FAIL LED - CHANNEL 1
- OFF = No CALL Output
- ON (Green) = CALL Output
- ON (Red) = Loop Failure

PRESENCE or PULSE - CHANNEL 1
- OFF = Pulse Mode
- ON = Presence Mode

FREQUENCY SETTING - CHANNEL 1
- 0 = Highest
- 3 = Lowest

DETECT / FAIL LED - CHANNEL 2
- OFF = No CALL Output
- ON (Green) = CALL Output
- ON (Red) = Loop Failure

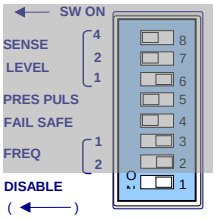
PRESENCE or PULSE - CHANNEL 2
- OFF = Pulse Mode
- ON = Presence Mode

FREQUENCY SETTING - CHANNEL 2
- 0 = Highest
- 3 = Lowest

Section 6 Installation and Set-Up

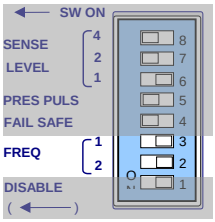
Each channel has a front panel mounted eight-position DIP switch module to control the operation of the channel. The various switches can be set before or after the detector card is inserted into a card rack wired with appropriate contact assignments The PRES PULSE, FAIL SAFE, and DISABLE switches can be pre-selected for the desired mode(s) of operation. The SENSE LEVEL and FREQ switches may require adjustment after the detector card has been inserted into the card rack. When the detector is inserted into the card rack, each channel will automatically tune to the loop circuit and begin operation within two seconds.

6.1 FRONT PANEL PROGRAMMING DIP SWITCHES



Channel Disable: When DIP switch 1 is in the ON position, the channel is disabled. Disabling a channel causes its output to remain in the NO CALL state. This switch is typically turned ON when a detector channel is not being used or has no loop connected to it. Disabling a channel will keep the channel's Detect / Fail LED from displaying a loop fail indication when the channel does not have a loop connected to it. When a channel is disabled, its loop oscillator is disabled as well. The factory default setting is OFF (Channel Disable Off).

NOTE: Changing the setting of this switch will reset the channel.

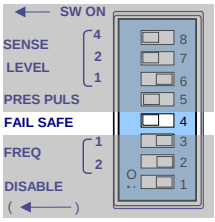


Frequency: The Model 222 detector sequentially activates each channel's loop circuit; so crosstalk between adjacent loops connected to different channels of the same detector is normally not a concern. Adjacent loops connected to different detectors may crosstalk. This may require changing the operating frequency of one of the loop circuits. If crosstalk is a problem, select another loop frequency for stable operation. Each channel of the Model 222 has four frequency selections that allow altering the resonant frequency of the loop circuit. The four frequency selections are selected with two switches marked 2 and 3 on the DIP switch module. The value (1 or 2) to the left of the DIP switch is assigned to the switch when the switch is ON. If the switch is OFF, the switch has a value of zero (0). By adding the switch ON and OFF values, the two switches can combine for values from 0 to 3 that indicate one of the four frequency selections. Use the following table as a reference for the switch selections and frequency settings. The factory default setting of these switches is switch 2 OFF and switch 3 OFF (HI).

NOTE: After changing any frequency switch setting(s), it is necessary to reset the detector channel by momentarily changing one of the other switch positions.

Frequency	DIP Switch 2	DIP Switch 3	Switch Values
HI *	OFF *	OFF *	0 + 0 = 0 *
MED HI	ON	OFF	1 + 0 = 1
MED LO	OFF	ON	0 + 2 = 2
LO	ON	ON	1 + 2 = 3

* Factory default setting.

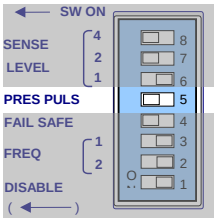


Fail-Safe / Fail-Secure: DIP switch 4 sets the default state of the channel's output when a loop failure condition exists on the loop network connected to the channel. One of two output states, shown in the table below, can be selected during a loop failure condition.

Operation	Detect / Fail LED	Output State
Fail-Safe	Solid ON (Red) Or One Hz flash rate (Red)	CALL
Fail-Secure	Solid ON (Red) Or One Hz flash rate (Red)	NO CALL

When the switch is in the ON position, the Fail-Safe mode of operation is selected. Fail-Safe operation during a loop failure is the standard mode of operation for intersection control. When the switch is in the OFF position, the Fail-Secure mode of operation is selected. Fail-Secure operation during a loop failure is typically used in incident detection systems for freeway management. Selecting Fail-Secure operation also selects Fast Response (see Response Time in Section 3). The factory default setting of this switch is ON (Fail-Safe Mode).

NOTE: Changing the setting of this switch will reset the channel.



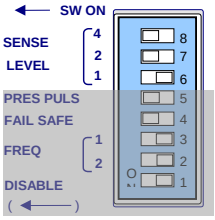
Presence / Pulse Output Mode: One of two output modes can be selected for each channel via DIP switch 5.

PRESENCE (PRES): When the switch is in the ON position, Presence Mode is selected. Presence Mode provides a CALL hold time of at least four minutes (regardless of vehicle size) and typically one to three hours for an automobile or truck. This is the factory default setting and the most common setting.

NOTE: A minimum 100 millisecond presence output time can be selected by setting DIP switch 2 of the two position DIP switch module labeled SW1 located on the PC board to the ON position. When the switch is in the OFF position, the presence time reflects the actual time the vehicle is over the loop.

PULSE (PULS): When the switch is in the OFF position, Pulse Mode is selected. Pulse Mode will generate a single 125 millisecond pulse output for each vehicle entering the loop detection zone. Any vehicle remaining in the loop detection zone longer than two seconds will be tuned out providing full sensitivity for the vacant portion of the loop detection zone. Full sensitivity for the entire loop detection zone is recovered within one second following the departure of any vehicle that has occupied the loop detection zone longer than two seconds.

NOTE: Changing the setting of this switch will reset the channel.



Sensitivity: Each channel has eight sensitivity levels that are selected with three switches marked 6, 7, and 8 on the DIP switch module. The value (1, 2, or 4) to the left of the DIP switch is assigned to the switch when the switch is ON. If the switch is OFF, the switch has a value of zero (0). By adding the switch ON and OFF values, the three switches can combine for values from 0 to 7 that indicate one of the eight sensitivity levels selections. Choose the lowest sensitivity level that will consistently detect the smallest vehicle that must be detected. Do not use a sensitivity level any higher than necessary. The following table shows the actual sensitivity (-ΔL/L threshold) for each of the sensitivity levels. The factory default setting of these switches is switch 6 OFF, switch 7 ON, and switch 8 ON (Sensitivity Level 6, -ΔL/L = 0.02%).

NOTE: Changing the sensitivity setting will reset the channel.

Sensitivity Level	Industry Reference	Typical Loop Size	Switch Values	-ΔL/L Threshold
0			0 + 0 + 0 = 0	1.28%
1			1 + 0 + 0 = 1	0.64%
2	Low		0 + 2 + 0 = 2	0.32%
3			1 + 2 + 0 = 3	0.16%
4	Normal	One 6’ x 6’	0 + 0 + 4 = 4	0.08%
5			1+ 0 + 4 = 5	0.04%
6	High	Four 6’ x 6’ Or One 6’ x 50’	0 + 2 + 4 = 6	0.02%
7			1 + 2 + 4 = 7	0.01%

6.2 FRONT PANEL MOUNTED PUSHBUTTON – AUDIBLE DETECT SIGNAL (BUZZER)

The pushbutton on the front panel labeled BUZZER is used to enable an Audible Detect Signal. When this feature is enabled (ON), an audible signal will be activated whenever the detection zone for the selected channel is occupied. The audible signal indicates actual occupancy of the loop detection zone. Only one channel can be turned on at a time. Turning this feature on for one channel automatically turns it off for the other channel. To activate this feature, press the pushbutton. The first time the pushbutton is pressed, a short (50 millisecond) audible signal confirms the activation of the feature for Channel 1. The second time the pushbutton is pressed, two short (50 millisecond) audible signals confirm the activation of the feature for Channel 2. To deactivate this feature, press and hold the pushbutton for one second. A long (250 millisecond) audible signal confirms the deactivation of the feature. This feature is automatically disabled 15 minutes after activation or on loss of power.

NOTE: When operating in Pulse Mode, the audible detect signal will cease once a vehicle has occupied the detection zone for more than two seconds.

6.3 LED INDICATORS

The detector has one super bright, high intensity, two color (green / red) light emitting diode (LED) per channel to indicate a CALL output and/or the status of any current or prior loop failure conditions.

6.3.1 DETECT INDICATIONS

A continuous ON (green) state indicates a CALL output.

If either channel has the audible detect feature activated, that channel's Detect / Fail LED will be illuminated in an orange state for any CALL output condition.

Detect / Fail LED	Meaning
OFF	No Detect (NO CALL Output)
Solid ON (Green)	Detect (CALL Output)
Solid ON (Orange)	Audible Detect Signal Activated Detect (CALL Output)

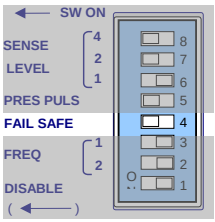
6.3.2 LOOP FAILURE INDICATIONS

A continuous ON (red) state indicates that a current open loop failure condition or an inductance change condition of greater than +25% exists. This indication also generates a CALL output if the channel is set to operate in Fail-Safe Mode. If set to operate in Fail-Secure Mode, a CALL output is not generated. A one Hz (red) flash rate indicates that a current shorted loop failure condition or an inductance change condition of greater than -25% exists. This indication also generates a CALL output if the channel is set to operate in Fail-Safe Mode. If set to operate in Fail-Secure Mode, a CALL output is not generated. A flash rate of three 50 millisecond (red) pulses indicates a prior loop failure condition. A flash rate of three 50 millisecond (red) pulses followed by a single 750 millisecond (green) pulse indicates a prior loop failure condition and a current CALL output (detect state).

If either channel has the audible detect feature activated, that channel's Detect / Fail LED will be illuminated in an orange state for any CALL output condition.

Detect / Fail LED	Meaning
OFF	No Loop Failure Condition (NO CALL Output)
Solid ON (Red)	Open Loop Failure Or Inductance change condition of greater than +25% exists
One Hz flash rate (Red) (50% Duty Cycle)	Shorted Loop Failure Or Inductance change condition of greater than -25% exists
Three 50 ms (Red) flashes per second	Loop Failure condition occurred but no longer exists
Three 50 ms (Red) flashes per second followed by a single 750 ms (Green) flash	Loop Failure condition occurred but no longer exists and Detect (CALL Output)
Three 50 ms (Red) flashes per second followed by a single 750 ms (Orange) Flash	Loop Failure condition occurred but no longer exists Audible Detect Signal Activated and Detect (CALL Output)

6.3.3 FAIL SAFE / FAIL-SECURE OPERATION AND OUTPUT STATES



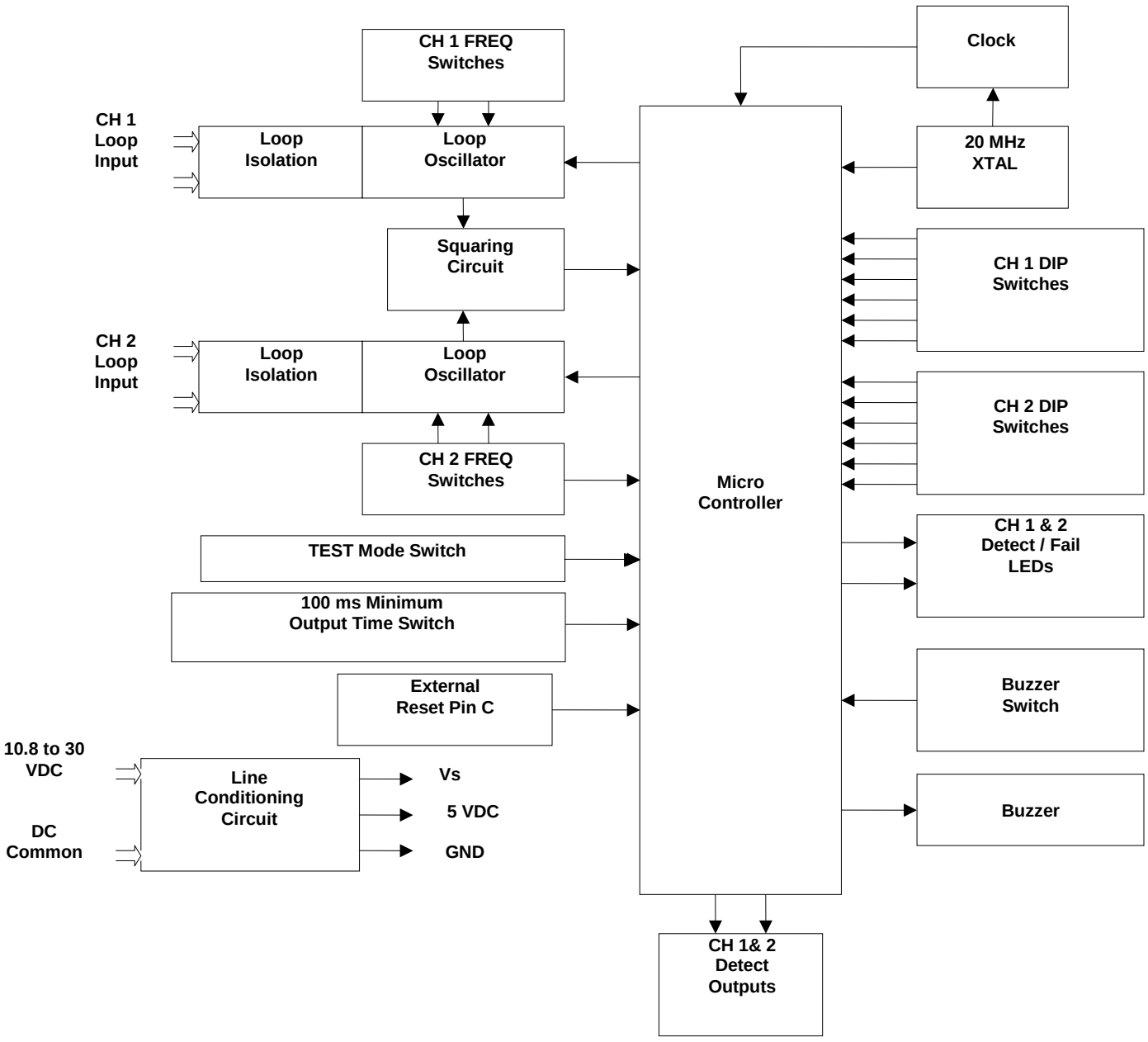
Fail-Safe / Fail-Secure: Operation in Fail-Safe or Fail-Secure Mode defines the default state of the channel output when a loop failure condition exists. One of two output states, shown in the table below, can be selected during a loop failure condition.

Operation	Detect / Fail LED	Output State
Fail-Safe (DIP Switch 4 ON)	Solid ON (Red) Or One Hz flash rate (Red)	CALL
Fail-Secure (DIP Switch 4 OFF)	Solid ON (Red) Or One Hz flash rate (Red)	NO CALL

6.4 RESET

Changing the position of any of an individual channel's front panel mounted DIP switches (except the Frequency or Fail-Safe / Fail-Secure switches) resets the channel. When the detector is installed and operating, the most convenient method for resetting is to momentarily change the position of the PRES PULS DIP switch and then return it to its original position. The detector can also be reset by connecting a logic ground signal to Contact C of the edge card connector or by the reapplication of power after a power loss.

Section 7 Block Diagram



Section 8 Theory of Operation

The Reno A&E Model 222 Detector digitally measures changes in the resonant frequency of two independent parallel tuned resonant circuits (loop / lead-in) to determine if a vehicle has entered the detection zone(s). The detector applies an excitation voltage to each loop circuit resulting in the loop oscillating at its resonant frequency. The current flow in the loop wire creates magnetic fields around the loop wire. When a vehicle passes over the loop area, the conductive metal of the vehicle causes a loading of the loop's magnetic fields. The loading decreases the loop inductance, which causes the resonant frequency to increase. By continuously sampling the loop's resonant frequency, the magnitude and rate of change can be determined. If the frequency change exceeds a selectable threshold (set by the sensitivity settings), the detector will activate an output signal. If the rate of change is slow, typical of environmental drift, the detector will continuously track and compensate for the change. The detector also monitors the loop frequency for out of range conditions such as an open or shorted loop circuit.

The detector scans the loop / lead-in circuit connected to each detector channel. The scanning method alternates the on and off cycle of each channel's loop circuit. Each channel's oscillator circuit supplies the excitation voltage that is coupled to the loop circuit by a loop isolation transformer. The transformer provides high common mode isolation between the loop and detector electronics, which allows the detector to operate on poor quality loops including a single short to ground. The transformer also limits the amount of static energy (lightning) that can transfer to the detector electronics. A spark gap transient suppression device is connected across the loop inputs to the isolation transformer. This device will dissipate static charges prior to their reaching the transformer. The loop input is also filtered for 60-cycle noise. A network of three capacitors is connected to the detector side of the isolation transformer. The capacitors can be switched in or out of the oscillator circuit to shift the frequency of the loop circuit, thus providing frequency separation between adjacent loops.

The sine wave from the loop circuit is squared to permit the microcontroller to digitally measure the period of several cycles. A high-speed clock sets a reference count for the period in a counter. If the frequency increases, the period is shorter and the period count decreases. By comparing the new count with the reference count, a percentage of change can be calculated that indirectly relates to the inductance change. If the magnitude of the change exceeds a selectable threshold (sensitivity setting), the detector activates the output device.

The rate of change is also monitored. Slow rates of change typical of environmental drift are tracked and automatically compensated for. If the total inductance of the loop input network goes out of the range specified for the detector, or rapidly changes by more than ±25%, the channel will immediately enter the programmed Fail-Safe or Fail-Secure mode of operation. Fail-Safe operation generates a continuous call output in the Presence Mode or Pulse Mode. Fail-Secure operation does not generate a call during the loop failure. In both modes of operation, the Detect / Fail LED will turn on (red) or flash (red) at a one Hz rate and remain on or continue flashing as long as the loop failure condition exists. If the loop self-heals, the channel will resume operation in a normal manner; except the Detect / Fail LED will begin to flash at a rate of three red flashes per second, thus providing an alert of a prior Loop Fail condition. The Detect / Fail LED will continue indicating the last loop failure condition until the detector is manually reset or power is removed.

8.1 DETAILED DESCRIPTION OF CIRCUIT OPERATION

The Reno A&E Model 222 detector is a microprocessor based unit that digitally measures changes in the resonant frequency of two independent parallel tuned resonant circuits (loop / lead-in) to determine if a vehicle has entered the detection zone(s). The detector applies an excitation voltage to each loop circuit resulting in the loop oscillating at its resonant frequency. The current flow in the loop wire creates magnetic fields around the loop wire. When a vehicle passes over the loop area, the conductive metal of the vehicle causes a loading of the loop's magnetic fields. The loading decreases the loop inductance, which causes the resonant frequency to increase. By continuously sampling the loop's resonant frequency, the magnitude and rate of change can be determined. If the frequency change exceeds a selectable threshold (set by the sensitivity settings), the detector will activate an output signal. If the rate of change is slow, typical of environmental drift, the detector will continuously track and compensate for the change, thus preventing false outputs without loss of sensitivity. The detector also monitors the loop frequency against predetermined tolerances for out of range conditions such as an open or shorted loop circuit. A loop fail condition occurs whenever the loop inductance exceeds predetermined high and low limits or the nominal operating inductance value rapidly changes by more than +/- 25%.

The detector is designed to operate from D.C. power sources providing either 12 VDC or 24 VDC. On-board regulators provide regulated voltages so that the detector can safely operate over the full input voltage range of 10.8 VDC to 30 VDC. The unit is also provided with an external reset capability. When Contact C of the edge card connector receives a logic ground signal for a minimum of 30 microseconds, both channels of the detector are immediately reset. Changing any front panel switch (except the frequency switches) resets the associated channel.

The detector operates on the scanning principle; i.e., each channel is alternately activated so that only one channel is active at any given time. This scanning operation ensures minimum crosstalk between channels. The detector has two independent loop oscillator circuits which are alternately turned on and off under the control of a programmed microprocessor. The frequency of each loop oscillator circuit is normally in the range of 20 KHz to 100 KHz and is established by the loop/lead-in network and the amount of added parallel capacitance. The amount of added capacitance is controlled by the front panel frequency switches. The greater the amount of added capacitance the lower the loop frequency. Each channel includes an isolation transformer (with transient voltage suppression) to provide high common mode rejection between the loop/lead-in networks and also provide added stability should the loop wire have a leakage path to ground. A filter is provided in the loop circuit which reduces interference problems resulting from 60-Hertz field noise in close proximity to the loop.

The output voltage from each of the two oscillator circuits is gated to a common comparator circuit that provides a square wave signal. The loop frequency signal from the comparator is then divided by two through a conventional flip flop IC. The flip flop provides a perfect square wave signal at one half the actual loop frequency. A dual JK flip flop is used in conjunction with the microprocessor to insure that the microprocessor receives a highly accurate time period which is representative of the loop inductance. The frequency of the loop is determined by measuring the time period for a fixed number of oscillations of the loop frequency signal. Whenever the loop frequency changes, the time period also changes. By accurately measuring the time period with a high frequency crystal clock signal rather than directly measuring loop frequency the detector is able to respond to small loop inductance changes in a very short time. Fast detector response time is desirable when the detector is used in speed and/or occupancy applications.

The operating parameters of each detector channel are established by DIP switch settings on DIP switch modules located on the front panel or PC board. Operating parameters that can be selected on the front panel are Sensitivity, Presence / Pulse Mode, Fail-Safe / Fail-Secure Operation, Loop Frequency, and Channel Disable. Operating parameters that can be selected on the PC board are Test Mode and 100 Millisecond Minimum Presence Output. The loop frequency switches are directly connected to the tuning capacitors in the loop oscillator circuits. The settings of the remaining switches are strobed into the microprocessor. The microprocessor provides two output signals, a separate output line for each channel. Each output line drives an optically isolated output. Solid state output devices provide faster turn on and turn off times, thus giving more accurate information when the detector is used in speed and/or occupancy applications. The output signals are indicated by two, dual color (green / red), front panel mounted Detect / Fail LEDs. Each LED corresponds to an individual detector channel. The Detect / Fail LEDs are normally extinguished when there are no detect outputs, the loops are in tolerance, and there have been no previous failure conditions. A Detect / Fail LED will be steady ON (green) when a current detect output state exists. A Detect / Fail LED will be steady ON (red) when a current open loop failure or an inductance change condition of more than 25% exists. A Detect / Fail LED will flash at a one Hz rate (red) when a current shorted loop failure or an inductance change condition of less than 25% exists. When a Detect / Fail LED flashes at a rate of three 50 millisecond flashes per second (red), it is an indication that the loop is currently in tolerance, but the detector channel has previously experienced an out of tolerance condition. If a current detect output state exists and a detector channel has previously experienced an out of tolerance condition, the corresponding Detect / Fail LED will flash at a rate of three 50 millisecond flashes per second (red) followed by a single 750 millisecond flash (green). Either of these prior failure Detect / Fail LED flashing conditions will be reset whenever the detector is reset, the channel is reset, or power is interrupted.

The detector offers a choice of operation in either Fail-Safe or Fail-Secure Mode. Fail-Safe operation is the proper choice for intersection control applications where the detector should output a vehicle detect condition in the event a loop failure condition. Fail-Secure operation is the proper choice for freeway management applications where it is undesirable for the detector to output a vehicle detect condition for a loop failure condition. A vehicle detect condition on a freeway would be considered a stalled vehicle. When the detector is operated in the Fail-Secure Mode, the detector offers a faster response time than it does when operated in the Fail-Safe Mode. Slightly slower response times in the Fail-Safe Mode allow more filtering, hence providing more noise immunity for intersection control applications.

Section 9 Preventative Maintenance

The Reno A&E Model 222 detector requires no maintenance. Proper operation requires that the inductive loop circuit(s) connected to the detector is (are) within the range of operating parameters designed into the detector.

9.1 TROUBLESHOOTING

SYMPTOM	POSSIBLE CAUSE	POSSIBLE CURE
Detector does not operate.	No power to detector.	• Verify that +10.8 to +30 VDC is supplied to pin B of the detector.
A channel's DETECT / FAIL LED is solid ON (Red).	The loop network is open or the loop inductance value has rapidly changed by more than +25% from its initial operating value.	• Ensure that all loop connections (including crimped connectors) are tight and secure and that no open connections exist. (If connections are not soldered, soldering is highly recommended.) • Verify the continuity of the loop circuit wires. The resistance of the loop network normally should be less than 5 ohms. • Remove and/or replace any defective lightning protection devices that are connected across loop wires external to the detector. Faulty suppression devices have been known to cause unstable detector operation. • Verify that the lead-in cable drain wire is completely isolated and insulated from earth ground in the pull box. • The problem could be an open (or intermittent open) loop condition, an open connection between the loop and the lead-in wire, or other open connections between the loop and the detector terminals. Check the integrity of all splices. • For trouble free operation, it is highly recommended that all loop and lead-in connections (including crimped connectors) be soldered and that the two loop lead-in wires for each loop, or set of loops, consist of a twisted pair of wires.
A channel's DETECT / FAIL LED is flashing (Red) at a One Hz rate (50% duty cycle).	The loop network is shorted or the loop inductance value has rapidly changed by more than -25% from its initial operating value.	• Ensure that all loop connections (including crimped connectors) are tight and secure and that no shorted connections exist. (If connections are not soldered, soldering is highly recommended.) • Remove and/or replace any defective lightning protection devices that are connected across loop wires external to the detector. Faulty suppression devices have been known to cause unstable detector operation. • Verify that the lead-in cable drain wire is completely isolated and insulated from earth ground in the pull box. • The problem could be a shorted (or intermittent shorted) loop condition, a shorted connection between the loop and the lead-in wire, or other shorted connections between the loop and the detector terminals. Check the integrity of all splices. • For trouble free operation, it is highly recommended that all loop and lead-in connections (including crimped connectors) be soldered and that the two loop lead-in wires for each loop, or set of loops, consist of a twisted pair of wires.
A channel's DETECT / FAIL LED is flashing (Red) at a rate of three 50 ms flashes per second.	Loop failure condition has occurred but no longer exists.	• Ensure that all loop connections (including crimped connectors) are tight and secure and that no open or shorted conditions may intermittently occur. Solder crimped connectors if the problem persists. • Remove and/or replace any defective lightning protection devices that are connected across loop wires external to the detector. Faulty suppression devices have been known to cause unstable detector operation. • Where possible, inspect the loop saw cut(s) for protruding wires and/or damaged sealant. • An intermittent connection can occur almost anywhere in the loop network. The most likely places are those places where joints (connections) are made such as between the lead-in wire and the detector card rack, in a pull box, or between the lead-in wire and the loop itself. • For trouble free operation, it is highly recommended that all loop and lead-in connections (including crimped connectors) be soldered and that the two loop lead-in wires for each loop, or set of loops, be a twisted pair of wires. Check the integrity of the splices.
Motorcycles are not reliably detected.	Multiple loops in a single loop network are not connected in series.	• Connect all loops in a single loop network in series. Parallel and series / parallel networks can lower detection sensitivity. • Increase the sensitivity level just enough to reliably detect motorcycles.

9.2 TEST MODE OPERATION

Test Mode uses the microcontroller to verify the proper operation of the detector's controls and indicators (switches and LEDs). Each channel's loop oscillator circuit is also checked to verify the correct frequency in each of the four frequency selections. The frequency portion of the test requires the detector to be connected to a 100 microhenry loop. If an inductance value other than 100 microhenries is used, the frequency test results will be invalid.

NOTE: The test procedures outlined below should not be performed in an operational traffic signal cabinet.

Test Procedure (PC Board Mounted DIP switches):

STEP 1. Remove power from the detector.
STEP 2. Set all front panel Channel 1 programming DIP switches (SW2) to the *OFF* position.
STEP 3. Set all front panel Channel 2 programming DIP switches (SW32) to the *OFF* position.
STEP 4. Set all PC board mounted DIP switches (SW1) to the OFF position.
STEP 5. Insert the detector into a suitable test fixture and apply power. Both of the detector's LED indicators should be OFF. Set the TEST switch (switch 1 on the PC board mounted DIP switch module, SW1) to the ON position. Both LED indicators should remain OFF. ***NOTE: To test the frequency range the channel must be connected to a 100 microhenry loop. The other tests may be performed with loops within the range of 20 to 2000 microhenries.***
STEP 6. Turn ON the 100 ms Minimum Output switch on the PC board mounted DIP switch module (SW1). The detector's Channel 1 Detect / Fail LED should turn ON (Red).
STEP 7. Turn OFF the 100 ms Minimum Output switch on the PC board mounted DIP switch module (SW1). The detector's Channel 1 Detect / Fail LED should turn OFF.
STEP 8. Remove power from the detector.

Test Procedure (Programming DIP switches):

STEP 1. Remove power from the detector.
STEP 2. Set all front panel Channel 1 programming DIP switches (SW2) to the *OFF* position.
STEP 3. Set all front panel Channel 2 programming DIP switches (SW3) to the *OFF* position.
STEP 4. Set all PC board mounted DIP switches (SW1) to the *OFF* position.
STEP 5. Insert the detector into a suitable test fixture and apply power. Both of the detector's LED indicators should be OFF. Set the TEST switch (switch 1 on the PC board mounted DIP switch module, SW1) to the ***ON*** position. Both LED indicators should remain OFF. ***NOTE: To test the frequency range the channel must be connected to a 100 microhenry loop. The other tests may be performed with loops within the range of 20 to 2000 microhenries.***
STEP 6. Individually, turn ON switches 8, 7, 6, 5, 4, and 1 of the Channel 1 programming DIP switch module (SW2). Turn OFF each switch after verifying the results indicated in the table below.

Switch Label	Switch #	LED Indications and Outputs
SENSE LEVEL 4	8	CH 1 DETECT / FAIL LED ILLUMINATED - GREEN
SENSE LEVEL 2	7	CH 1 DETECT / FAIL LED ILLUMINATED - RED
SENSE LEVEL 1	6	CH 1 DETECT / FAIL LED ILLUMINATED - GREEN
PRES PULS	5	CH 1 DETECT / FAIL LED ILLUMINATED - RED
FAIL SAFE	4	CH 1 DETECT / FAIL LED ILLUMINATED - GREEN
DISABLE	1	CH 1 DETECT / FAIL LED ILLUMINATED - RED

STEP 7. Individually, turn ON switches 8, 7, 6, 5, 4, and 1 of the Channel 2 programming DIP switch module (SW3). Turn OFF each switch after verifying the results indicated in the table below.

Switch Label	Switch #	LED Indications and Outputs
SENSE LEVEL 4	8	CH 2 DETECT / FAIL LED ILLUMINATED - GREEN
SENSE LEVEL 2	7	CH 2 DETECT / FAIL LED ILLUMINATED - RED
SENSE LEVEL 1	6	CH 2 DETECT / FAIL LED ILLUMINATED - GREEN
PRES PULS	5	CH 2 DETECT / FAIL LED ILLUMINATED - RED
FAIL SAFE	4	CH 2 DETECT / FAIL LED ILLUMINATED - GREEN
DISABLE	1	CH 2 DETECT / FAIL LED ILLUMINATED - RED

STEP 8. Remove power from the detector.

Test Procedure (Frequency DIP switches):

STEP 1. Remove power from the detector.
STEP 2. Set all front panel Channel 1 programming DIP switches (SW2) to the *OFF* position.
STEP 3. Set all front panel Channel 2 programming DIP switches (SW3) to the *OFF* position.
STEP 4. Set all PC board mounted DIP switches (SW1) to the *OFF* position.
STEP 5. Insert the detector into a suitable test fixture and apply power. Both of the detector's LED indicators should be OFF. Set the TEST switch (switch 1 on the PC board mounted DIP switch module, S3) to the ***ON*** position. Both LED indicators should remain OFF. ***NOTE: To test the frequency range the channel must be connected to a 100 microhenry loop. The other tests may be performed with loops within the range of 20 to 2000 microhenries.***

STEP 6. Individually, turn ON switches 3 and 2 of the Channel 1 programming DIP switch module (SW2). Turn OFF each switch after verifying the results indicated in the table below.

Switch Label	Switch #	LED Indications and Outputs
FREQ 1	3	CH 1 DETECT / FAIL LED ILLUMINATED - GREEN
FREQ 2	2	CH 1 DETECT / FAIL LED ILLUMINATED - RED

STEP 7. Individually, turn ON switches 3 and 2 of the Channel 2 programming DIP switch module (SW3). Turn OFF each switch after verifying the results indicated in the table below.

Switch Label	Switch #	LED Indications and Outputs
FREQ 1	3	CH 2 DETECT / FAIL LED ILLUMINATED - GREEN
FREQ 2	2	CH 2 DETECT / FAIL LED ILLUMINATED - RED

STEP 8. Remove power from the detector.

An LED indication different than the ones described for each switch setting indicates the loop frequency is out of tolerance. Verify that the loop test coil has an inductance of 100 microhenries. If the test loop measures 100 microhenries the detector module should be serviced.

Test Procedure (Front Panel Buzzer switch):

STEP 1. Remove power from the detector.
STEP 2. Refer to the table in Section 4.5 and set all front panel programming DIP switches (SW1 and SW2) to their default positions.
STEP 3. Set all PC board mounted DIP switches (S3) to the *OFF* position.
STEP 4. Insert the detector into a suitable test fixture and apply power. Both of the detector's LED indicators should be OFF. ***NOTE: To test the frequency range, the channel must be connected to a 100 microhenry loop. The other tests may be performed with any loops within the range of 20 to 2000 microhenries.***
STEP 5. Press the front panel mounted switch labeled ***BUZZER***. The buzzer should sound once (50 ms).
STEP 6. Perform the actions and verify the results indicated in the table below.

Action	LED Indications and Outputs
INPUT CALL CHANNEL 1	• CHANNEL 1 DETECT / FAIL LED ILLUMINATED - ORANGE • BUZZER SOUNDS
REMOVE CALL CHANNEL 1	• CHANNEL 1 DETECT / FAIL LED OFF • BUZZER OFF

STEP 7. Press the front panel mounted switch labeled ***BUZZER***. The buzzer should sound twice (50 ms).
STEP 8. Perform the actions and verify the results indicated in the table below.

Action	LED Indications and Outputs
INPUT CALL CHANNEL 2	• CHANNEL 2 DETECT / FAIL LED ILLUMINATED - ORANGE • BUZZER SOUNDS
REMOVE CALL CHANNEL 2	• CHANNEL 2 DETECT / FAIL LED OFF • BUZZER OFF

STEP 9. Press the front panel mounted switch labeled ***BUZZER***. The buzzer should sound once (250 ms).
STEP 10. Remove power from the detector.

Test Procedure (Reset):

STEP 1. Remove power from the detector.
STEP 2. Refer to the table in Section 6.1 and set all front panel programming DIP switches (SW2 and SW3) to their default positions.
STEP 3. Set all PC board mounted DIP switches (SW1) to the ***OFF*** position.
STEP 4. Insert the detector into a suitable test fixture and apply power. Both of the detector's LED indicators should be OFF. ***NOTE: To test the frequency range, the channel must be connected to a 100 microhenry loop. The other tests may be performed with any loops within the range of 20 to 2000 microhenries.***

STEP 5. Perform the actions and verify the results indicated in the table below. NOTE: Unless otherwise noted, references to inputs in the table correspond to labels on test equipment supplied by Reno A&E.

Switch / Button / Input	Action	LED Indications and Outputs
CHANNEL 1 ***OPEN LOOP*** BUTTON	PRESS AND HOLD	• DETECTOR CHANNEL 1 DETECT / FAIL LED ILLUMINATED - RED • DETECTOR CHANNEL 1 OUTPUT ON • TEST FIXTURE CHANNEL 1 DETECT LED ON
CHANNEL 1 ***OPEN LOOP*** BUTTON	RELEASE	• DETECTOR CHANNEL 1 DETECT / FAIL LED FLASH - RED (THREE 50 ms FLASHES PER SECOND) • DETECTOR CHANNEL 1 OUTPUT OFF • TEST FIXTURE CHANNEL 1 DETECT LED OFF
RESET BUTTON	PRESS AND RELEASE	• DETECTOR CHANNEL 1 DETECT / FAIL LED OFF
CHANNEL 2 ***OPEN LOOP*** BUTTON	PRESS AND HOLD	• DETECTOR CHANNEL 2 DETECT / FAIL LED ILLUMINATED - RED • DETECTOR CHANNEL 2 OUTPUT ON • TEST FIXTURE CHANNEL 2 DETECT LED ON
CHANNEL 2 ***OPEN LOOP*** BUTTON	RELEASE	• DETECTOR CHANNEL 2 DETECT / FAIL LED FLASH - RED (THREE 50 ms FLASHES PER SECOND) • DETECTOR CHANNEL 2 OUTPUT OFF • TEST FIXTURE CHANNEL 2 DETECT LED OFF
RESET BUTTON	PRESS AND RELEASE	• DETECTOR CHANNEL 2 DETECT / FAIL LED OFF

STEP 6. Remove power from the detector.

9.3 VOLTAGE AND WAVEFORM MEASUREMENTS

The following voltage and waveform measurements are referenced to logic ground on Pin A of the edge card connector.

VOLTAGES:

1. Verify 10.8 to 27 VDC on Pin B of the edge card connector.
2. Verify 5 VDC on the following:
   Pin 3 of U5 (regulator)
   Pin 1 (Reset) and Pin 20 (VCC) of U6 (microcontroller).
3. Verify the operation of the crystal on Pin 21 of U6 (Figure 1).
4. Verify channel 1 and 2 oscillator scan signals (shown in Figure 2) on Pins 2 and 3 of U6 respectively.
5. Verify Channel 1 and 2 oscillator sine waveforms (Figure 3) across LA1 and LA2 (surge protectors). The sine wave should be 8 to 10 V peak-to-peak and between 20 and 100 kHz.
6. Verify the comparator square wave. Turn OFF one of the channels with the front panel DISABLE switch. Probe Pin 1 of U1 (Figure 4). Test both channels.

WAVE FORMS:

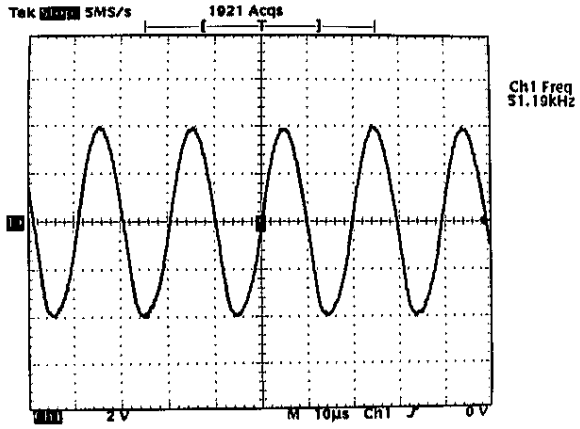


Figure 1.

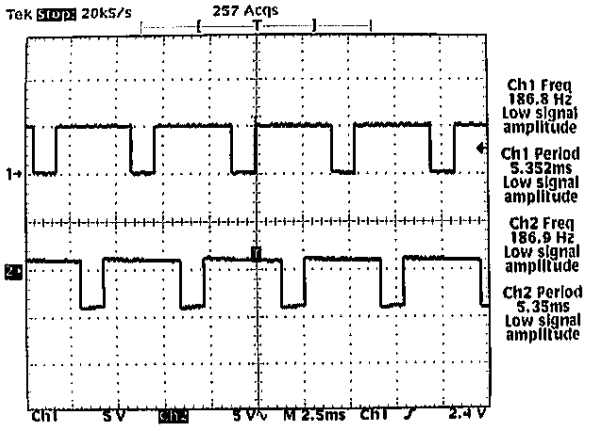


Figure 2.

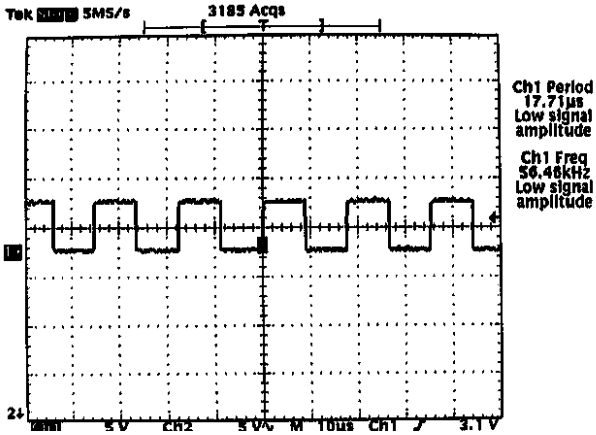


Figure 3.

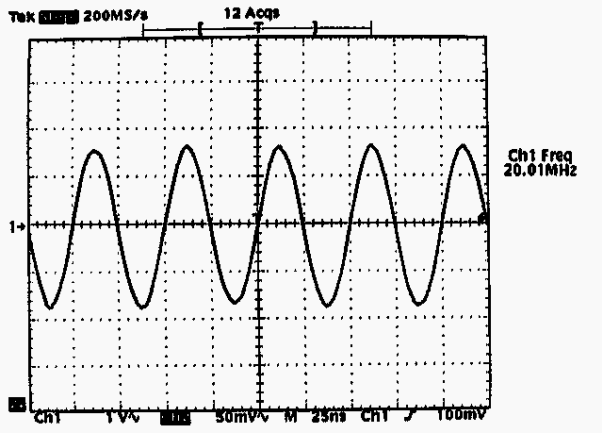
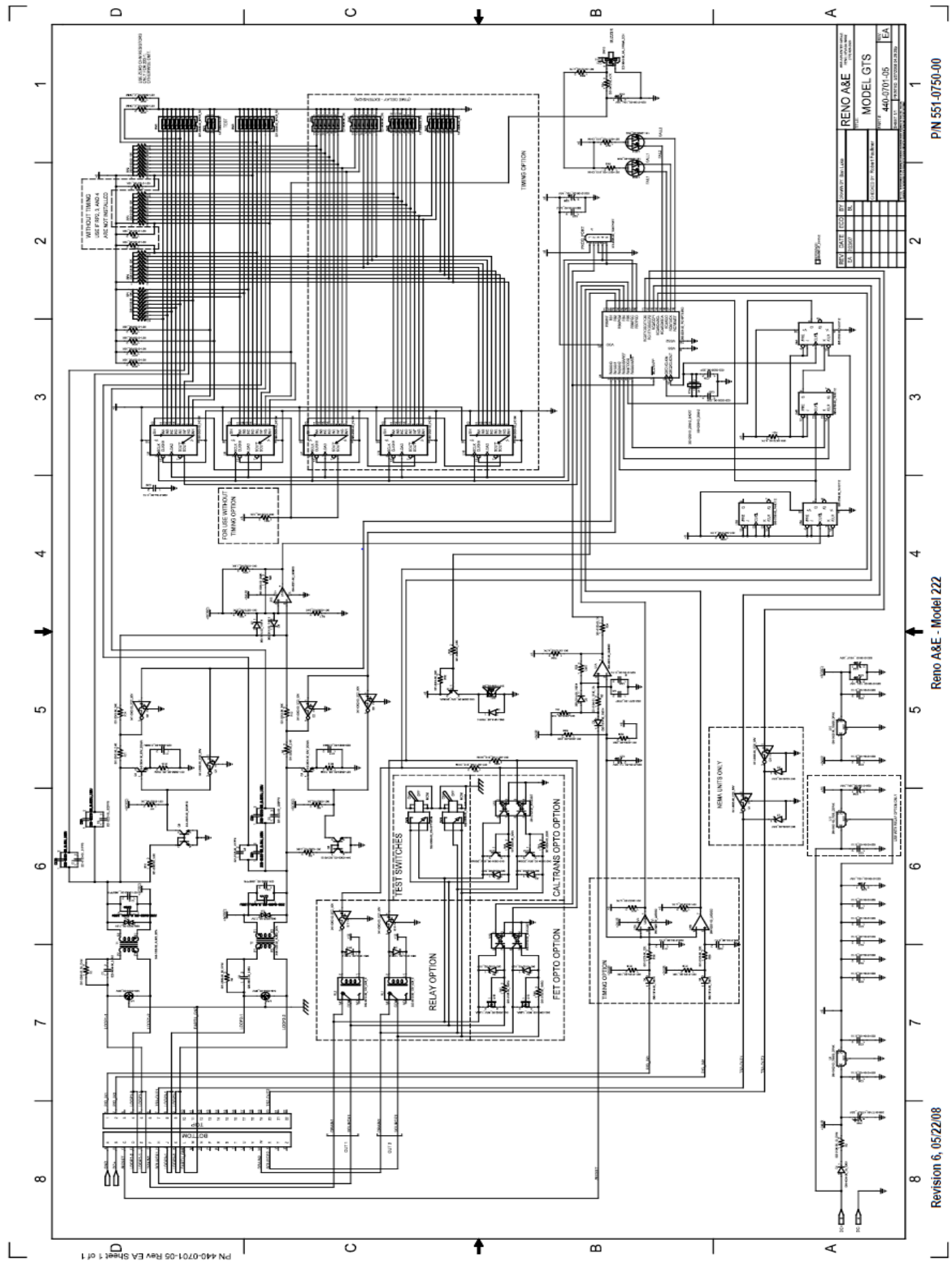


Figure 4.


RENO A&E
MODEL GTS
440-0701-05
EA
P/N 551-0750-00
Reno A&E - Model 222
Revision 6, 05/22/08
TEST SWITCHES
RELAY OPTION
CALTRANS OPTO OPTION
FET OPTO OPTION
TIMING OPTION
NEMA UNITS ONLY
FOR USE WITHOUT TIMING OPTION
PN 440-0701-05 Rev EA Sheet 1 of 1

Section 11 Parts List

MODEL 222 PRINTED CIRCUIT BOARD ASSEMBLY PARTS LIST: 400-0750-08			
SYMBOL	**P/N**	**DESCRIPTION**	**MANUFACTURER**
PCB	440-0701-05	CIRCUIT BOARD	RENO A & E
BZ1	357-7006-00	TH BUZZER, MAGNETIC	SHANGHAI TELEVISION
C1, C2	020-0684-00	SMT CAPACITOR, X7R, 0.68µF, 1812, 50V	KEMET
C3, C9	021-0223-00	SMT CAPACITOR, PPS, 0.022µF	PANASONIC
C6	022-0271-00	SMT CAPACITOR, NPO, 270ρF, 1206	KEMET
C8, C13	021-0103-00	SMT CAPACITOR, PPS, 0.01µF	PANASONIC
C14, C15	021-0683-00	SMT CAPACITOR, PPS, 0.068µF	PANASONIC
C17, C18	020-0683-00	SMT CAPACITOR, X7R, 0.068µF, 1206, 50V	AVX CORP.
C21	025-0105-00	SMT CAPACITOR, TANTALUM, 1µF, 35V, B PACKAGE	AVX
C22	226-0477-00	TH CAPACITOR, ELECTROLYTIC, 470µF, 35V	NICHICON
C23, C24	022-0220-00	SMT CAPACITOR, NPO, 22ρF, 0805	KEMET
C25, C26, C27, C29, C30, C31, C34, C35, C38, C40, C41	020-0104-00	SMT CAPACITOR, X7R, 0.1µF, 1206, 50V	KEMET
C28, C33, C39, C42	025-0106-00	SMT CAPACITOR, TANTALUM, 10µF, 16V, B PACKAGE	AVX
D1	064-4004-00	SMT DIODE, POWER, RECTIFIER, SMA	MOTOROLA
D2, D3, D6, D7, D8	060-1914-00	DIODE, SMALL SIGNAL, SOD123	ON-SEMI
J1	372-0005-00	CONNECTOR, STRIP, 5 PIN, FEMALE, TEST PORT	AMP
LA1, LA2	349-0004-00	TH TRANSIENT PROTECTION, SPARK GAP, 3 PRONG	CITEL
LED1, LED2	141-0000-00	SMT LED, 90 DEGREE, RED / GREEN	STANLEY
Q2, Q5, Q6, Q7	041-0002-00	SMT TRANSISTOR, DRIVER, NPN, SMT3, DTC114	ROHM
Q3, Q4, Q12, Q15	040-3904-00	SMT TRANSISTOR, SMALL SIGNAL, NPN, SOT23	MOTOROLA
Q8, Q9	044-0005-00	SMT TRANSISTOR, ARRAY, NPN, PAIR, COMMON BASE, BCV61B	PHILLIPS
Q10	040-3906-00	SMT TRANSISTOR, SMALL SIGNAL, PNP, SOT23	ON-SEMI
R1, R2	001-0390-00	SMT RESISTOR, 1206, 39 OHM	DALE
R3	002-0100-00	SMT RESISTOR, 2010, 10 OHM	PANASONIC
R4, R35, R36, R37, R38, R50, R51, R52	001-0103-00	SMT RESISTOR, 1206, 10K OHM	DALE
R5	001-0194-01	SMT RESISTOR, 1206, 191 OHM, 1%	PANASONIC
R6, R11	001-0242-00	SMT RESISTOR, 1206, 2.4K OHM	DALE
R7, R8	001-0302-00	SMT RESISTOR, 1206, 3K OHM	DALE
R9, R10, R33	001-0362-00	SMT RESISTOR, 1206, 3.6K OHM	ROHM
R12, R14, R17, R29, R30, R32	001-0243-00	SMT RESISTOR, 1206, 24K OHM	DALE
R13, R15	001-0680-00	SMT RESISTOR, 1206, 68 OHM	DALE
R20	001-0394-00	SMT RESISTOR, 1206, 390K OHM	DALE
R21	001-0273-00	SMT RESISTOR, 1206, 27K OHM	DALE
R24	001-0162-00	SMT RESISTOR, 1206, 1.6K OHM	DALE
R26, R28, R31, R53, R54	001-0472-00	SMT RESISTOR, 1206, 4.7K OHM, 5%	DALE
R34	001-0102-00	SMT RESISTOR, 1206, 1K OHM	DALE
R41	001-0123-00	SMT RESISTOR, 1206, 12K OHM	DALE
R44, R46	001-0224-00	SMT RESISTOR, 1206, 220K OHM	DALE
R42, R43, R48, R49	001-0511-00	SMT RESISTOR, 1206, 510 OHM, 5%	DALE
RP1	203-0103-00	TH RESISTOR, NETWORK, 10K OHM, SIP, 9 RESISTOR	DALE
SW1	121-0002-00	SMT SWITCH, DIP, 2 POSITION, FACE UP	CTS

SW2, SW3	**321-0008-00**	**TH SWITCH, DIP, 8 POSITION, RIGHT ANGLE**	**CTS**
SW10	**323-0645-00**	**TH SWITCH, PUSH-BUTTON, RIGHT ANGLE, BLACK, 6 X 6 MM**	**BOURNS**
T1, T2	**348-1002-02**	**TH TRANSFORMER, ISOLATION, POTCORE, AL800, G2**	**RENO A & E**
TZ1, TZ2	**068-0075-00**	**SMT DIODE, TRANSORB, 7.5V, SMB**	**GENERAL SEMICONDUCTOR**
U1	**094-0201-00**	**SMT LINEAR IC, COMPARATOR, LM393**	**ST MICRO**
U3, U4	**095-0700-00**	**SMT DIGITAL IC, LOGIC, 74HC112**	**ST MICRO**
U5, U10	**094-0402-00**	**SMT LINEAR IC, VOLTAGE REGULATOR, 78M05**	**ON-SEMI**
U6	**099-0004-00**	**SMT FLASH PROCESSOR, SOIC28, PIC16F73-I/SO, GT, 2.1**	**MICROCHIP**
U8, U9	**095-0000-00**	**SMT DIGITAL IC, LOGIC, 74HC165, SOIC, 8 BIT**	**ST MICRO**
U13	**094-0703-00**	**SMT LINEAR IC, OPTO COUPLER, MOCD207**	**VISHAY**
X1	**155-0206-00**	**SMT CRYSTAL, 20 MHZ**	**ECLIPTEK**
Z3, Z5	**067-0330-00**	**SMT DIODE, ZENER, 33V, SOD123**	**ON-SEMI**