

Model T-210

Loop Detector Operations Manual

Two Channel DIP Switch Programmable Inductive Loop Vehicle
Detector

This manual contains technical information for the

Model T-210 Loop Detector

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MANUFACTURED IN THE USA BY EBERLE DESIGN, INC. IN PHOENIX, ARIZONA.

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Model T-210 Operations Manual

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Section 1 General Description

This Operation Manual was written for people installing, operating, and troubleshooting Reno A & E Model T-210 inductive loop vehicle detectors. The Model T-210 inductive loop vehicle detector is a scanning, two channel, shelf-mount type loop detector with delay and extension timing. The Model T-210 is designed to meet or exceed the NEMA Standards TS 1-1989.

The Model T-210 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 mounted six-position DIP switch module to provide the following selections:

- Seven Sensitivity Levels ($-\Delta L/L\%$) and OFF.
- Presence or Pulse Mode.
- Four Frequency Selections.

Delay and extension timing settings of each channel are independently programmed with a twelve-position DIP switch module to provide delay timing intervals of 0 to 63 seconds and extension timing intervals of 0 to 15.75 seconds.

The Model T-210 sequentially 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.

If the total inductance of the loop input network goes out of the range specified for the detector, or rapidly changes by more than $\pm 25\%$, the channel will enter the programmed Fail-Safe mode of operation. Fail-Safe operation, generates a continuous CALL output state as long as a loop failure condition exists.

Each channel has a single, dual color (green / red) Detect / Fail LED indicator. The LED provides an indication of the channel's output state, delay and/or extension timing settings, 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.

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 for 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.

The Detect / Fail LED will illuminate (green) to indicate a vehicle presence in the loop area. If a prior Loop Failure condition has occurred and detection occurs, the Detect / Fail LED will flash (red) at a rate of three 50 millisecond flashes per second followed by a single 750 millisecond flash (green). This prior Loop Failure indication will continue until the detector is manually reset or power is removed.

In addition, the Reno A & E Model T-210 has a Test Mode that uses the microcontroller to verify the proper operation of the detector's controls and indicators (switches and LEDs). Each channel's loop oscillator circuit can also be tested to verify the correct frequency range in each of the four frequency selections.

The Model T-210 Series is comprised of the following detectors:

- | | |
|----------------|---|
| Model T-210-R | For NEMA TS-1 applications calling for a two channel, shelf mount detector with delay and extension timing and relay outputs. |
| Model T-210-SS | For NEMA TS-1 applications calling for a two channel, shelf mount detector with delay and extension timing and solid state outputs. |

Section 2 General Characteristics

2.1 LOOP FREQUENCY

There are four (4) selectable loop frequency settings (normally in the range of 20 to 100 kilohertz) for each channel. The actual loop operating frequency is a function of the loop / lead-in network and the components of the loop oscillator circuit. Adjacent loops connected to different detectors may crosstalk and require changing of the operating frequency of one of the loop circuits. If crosstalk is a problem, select another loop frequency for stable operation. The four frequency selections are controlled with two DIP switches (labeled 1 and 2) on each of the two front panel mounted six-position DIP switch modules.

NOTE: The detector channel must be RESET after changing the frequency setting.

2.2 PRESENCE / PULSE MODE

Two modes of operation for each channel of the detector are available. Presence or Pulse Mode is selected by setting the state of a DIP switch (labeled 3) on each of the two front panel mounted six-position DIP switch modules.

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.

PULSE MODE: An output Pulse of 125 ± 10 milliseconds 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.

NOTE: Changing the Presence / Pulse switch setting of an individual channel will RESET that channel.

2.3 SENSITIVITY

There are seven (7) selectable sensitivity levels plus OFF for each channel. The sensitivity levels are designed so that a one level increase actually doubles the sensitivity and a one level decrease halves the sensitivity. The seven sensitivity levels and OFF setting are selected via three DIP switches (labeled 4, 5, and 6) on each of the two front panel mounted six-position DIP switch modules. (See Section 3.4 for actual detection levels and response times for each sensitivity level.)

NOTE: Changing the sensitivity level setting of an individual channel will RESET that channel.

2.4 CALL EXTENSION

Each channel's Call Extension can be adjusted from 0 to 15.75 in ¼-second steps. Call Extension settings are controlled with six DIP switches (labeled 1 through 6) on each of the two front panel mounted twelve-position DIP switch modules. Call Extension time starts counting down when the last vehicle leaves the loop detection zone. In the event a vehicle enters the loop detection zone before the extension time expires, the detector will return to the detect state (regardless of the setting of the delay timer) and the extension timer will be reset. When the last vehicle leaves the loop detection zone, full Extension time is reestablished and the detector begins counting down again. The detector will indicate that the extension interval is currently timing by flashing the Detect / Fail LED at 16 Hz (green) with a 50% duty cycle. When operating in Pulse Mode, the 125 millisecond pulse output will be extended by the amount of time programmed into the Extension timer.

2.5 CALL DELAY

Each channel's Call Delay can be adjusted from 0 to 63 in one-second steps. Call Delay settings are controlled with six DIP switches (labeled 7 through 12) on each of the two front panel mounted twelve-position DIP switch modules. Call Delay time starts counting down when a vehicle first enters the loop detection zone. If the Delay feature is activated, the output will only be turned on after the selected delay time has passed with a vehicle continuously present in the loop detection area. If a vehicle leaves the loop detection area during the delay interval, detection is aborted and the next vehicle to enter the loop detection area will initiate a new full delay interval. Whenever a channel's Phase Green Input (call delay override) signal (pin J of the channel's front panel mounted connector) is active (high state), the Call Delay function for that channel is aborted and the Call delay time is forced to zero. The detector indicates that a vehicle is being detected, but that the outputs are being delayed, by flashing the Detect / Fail LED at four Hz (green) with a 50% duty cycle. When operating in Pulse Mode, the 125 millisecond pulse output will be delayed by the amount of time programmed into the Delay timer.

2.6 AUDIBLE DETECT SIGNAL

The push button 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.

2.7 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 3 Specifications

3.1 PHYSICAL

WEIGHT: 27.0 oz (963.9 gm).

SIZE: 6.45 inches (16.38 cm) high x 2.50 inches (6.35 cm) wide x 6.35 inches (16.13 cm) deep excluding connectors. Connectors add .675 inches (1.71 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.

CONNECTORS: Two (2) MS 3102A-18-1P 10 pin male. See Section 3.6 for pin assignments.

3.2 ELECTRICAL

POWER: 89 to 135 VAC, 50/60 Hz, 6 Watts 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: Meets and/or exceeds all applicable NEMA TS 1 specifications for transient voltage protection.

RESET: Meets and/or exceeds NEMA TS 1 detector specifications. Each detector channel can be manually reset by momentarily changing any switch position (except the frequency switches). The detector is also reset by pressing the front panel mounted reset push button or by the return of power after a power loss.

RELAY RATING: The relay contacts are rated for 6 Amps maximum, 150 VDC maximum, and 180 Watts maximum switched power.

SOLID STATE OUTPUT RATING: Optically isolated. 30 VDC maximum collector (drain) to emitter (source). 100 mA maximum saturation current. 2 VDC maximum transistor saturation voltage. The output is protected with a 33-volt Zener diode connected between the collector (drain) and emitter (source).

3.3 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. 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. A flash rate of three 50 millisecond (red) flashes indicates a prior loop failure condition. A flash rate of three 50 millisecond (red) flashes followed by a single 750 millisecond (green) flash 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 Detect / No Loop Failure Condition (No CALL Output)
Solid ON (Green)	Detect (CALL Output)
Solid ON (Orange)	Audible Detect Signal Activated, Detect (CALL Output)
Four flashes per second (Green)	Vehicle detected, Delay Timing active, No Detect (No CALL Output)
Four flashes per second (Orange)	Audible Detect Signal Activated, Vehicle detected, Delay Timing active, No Detect (No CALL Output)
16 flashes per second (Green)	Detection zone vacant, Extension Timing active, Detect (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)
Three 50 ms (Red) flashes per second followed by four flashes per second (Green)	Loop Failure condition occurred but no longer exists And Vehicle detected, Delay Timing active, No Detect (No CALL Output)
Three 50 ms (Red) flashes per second followed four flashes per second (Orange)	Loop Failure condition occurred but no longer exists, Audible Detect Signal Activated, And Vehicle detected, Delay Timing active, No Detect (No CALL Output)
Three 50 ms (Red) flashes per second followed by 16 flashes per second (Green)	Loop Failure condition occurred but no longer exists And Detection zone vacant, Extension Timing active, Detect (CALL Output)

RESPONSE TIME: Meets or exceeds NEMA TS 1 response time specifications. See *Sensitivity, -ΔI/L, & Typical Response Times* table 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 require 30 seconds of operation.

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

GROUNDING 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 (1500 m) 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 Fail-Safe mode of operation. The Fail-Safe mode of operation generates 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 return 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.

FAIL-SAFE OUTPUTS: A detection output (CALL) is indicated by a closed relay contact (Relay output) or a conducting state (Solid State output). A channel's output defaults to a CALL state for any loop failure condition on that channel or upon loss of power.

3.4 TABLE: SENSITIVITY, -ΔL/L, AND TYPICAL RESPONSE TIME

Sensitivity Level	Industry Reference	Switch 4	Switch 5	Switch 6	-ΔL/L Threshold	Response Time
0		OFF	OFF	OFF	OFF	-----
1		ON	OFF	OFF	0.64%	65 ±25 ms
2	Low	OFF	ON	OFF	0.32%	65 ±25 ms
3		ON	ON	OFF	0.16%	65 ±25 ms
4	Normal	OFF	OFF	ON	0.08%	65 ±25 ms
5		ON	OFF	ON	0.04%	65 ±25 ms
6	High	OFF	ON	ON	0.02%	65 ±25 ms
7		ON	ON	ON	0.01%	65 ±25 ms

3.5 TABLE: DEFAULT SETTINGS (FRONT PANEL MOUNTED DIP SWITCH)

DIP Switch	Function	Setting	Position
1			OFF
2	Frequency	0	OFF
3	Presence / Pulse Mode	Presence	ON
4			OFF
5	Sensitivity	6	ON
6			ON

3.6 TABLE: PIN ASSIGNMENTS

Channel 1 Connector

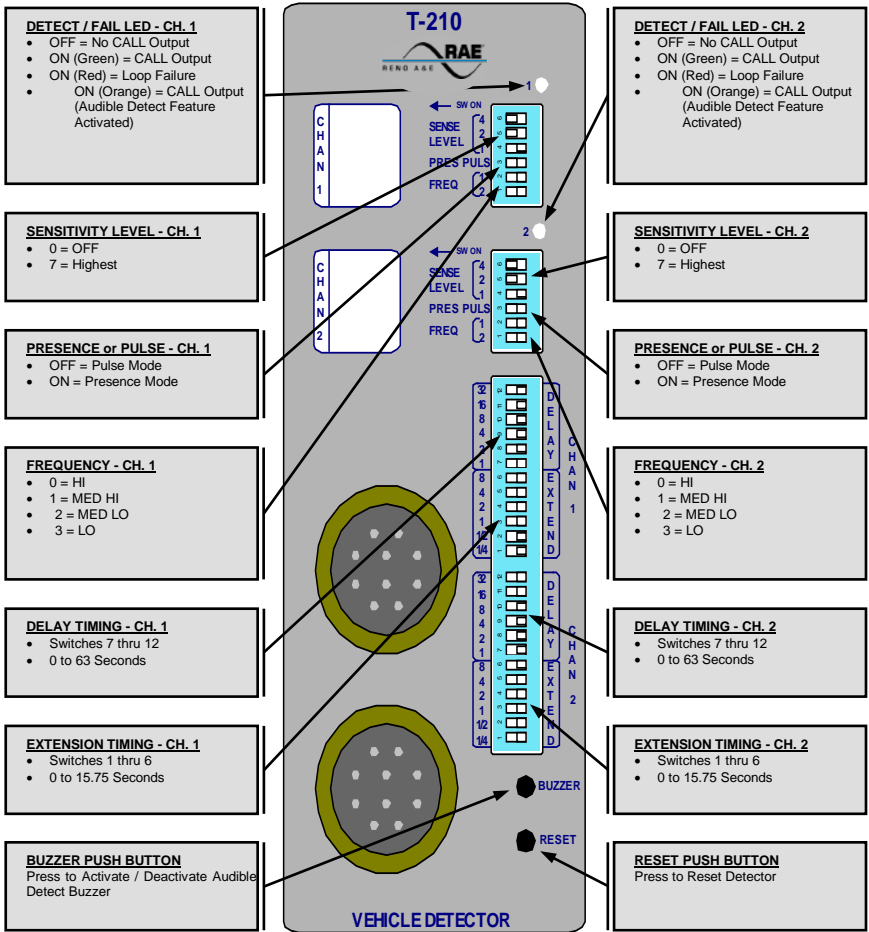
Pin	Function (Relay Outputs)	Function (Solid State Outputs)
A	Power, Neutral, 120 VAC	Power, Neutral, 120 VAC
B	Channel 1 Output, Relay Common	Channel 4 Output, Emitter (Source)
C	Power, Line, 120 VAC	Power, Line, 120 VAC
D	Channel 1 Loop Input	Channel 1 Loop Input
E	Channel 1 Loop Input	Channel 1 Loop Input
F	Channel 1 Output, Relay Normally Open	Channel 1 Output, Collector (Drain)
G	Channel 1 Output, Relay Normally Closed	No Connection
H	Chassis Ground	Chassis Ground
I	No Connection	No Connection
J	Channel 1 Phase Green Input	Channel 1 Phase Green Input

Channel 2 Connector

Pin	Function (Relay Outputs)	Function (Solid State Outputs)
A	No Connection	No Connection
B	Channel 2 Output, Relay Common	Channel 2 Output, Emitter (Source)
C	No Connection	No Connection
D	Channel 2 Loop Input	Channel 2 Loop Input
E	Channel 2 Loop Input	Channel 2 Loop Input
F	Channel 2 Output, Relay Normally Open	Channel 2 Output, Collector (Drain)
G	Channel 2 Output, Relay Normally Closed	No Connection
H	No Connection	No Connection
I	No Connection	No Connection
J	Channel 2 Phase Green Input	Channel 2 Phase Green Input

NOTE: Relay contact states are shown with power applied, loop(s) connected, and no vehicle(s) present.

Section 4 User Interface



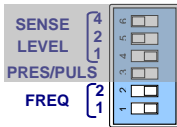
NOTE: There are no internal switches or jumpers to set.

Section 5 Installation and Set-Up

Each channel has a front panel mounted six-position DIP switch module to control the operation of the channel and a front panel mounted twelve-position DIP switch module to set Delay and/or Extension Timing. The various switches can be set before or after the harnesses have been connected to the detector. The PRES / PULSE switch can be pre-selected for the desired mode of operation. The SENSE LEVEL and FREQ switches may require adjustment after the harnesses have been connected. When power is applied to the detector, each channel will automatically tune to the loop circuit and begin operation within two seconds.

Connect the detector to an appropriately wired set of harnesses and apply power.

5.1 FRONT PANEL PROGRAMMING DIP SWITCHES



Frequency: The Model T-210 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 T-210 has four frequency selections that allow altering the resonant frequency of the loop circuit. The four frequency selections are controlled with two switches marked 1 and 2 on the DIP switch module. The values (1 and 2) to the left of the DIP switch are 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 1 OFF and switch 2 OFF (HI).

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

Frequency	Switch 2	Switch 1	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

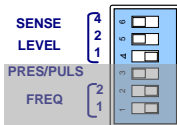
* Factory default setting.



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

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.

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.



Sensitivity: Each detector channel has seven sensitivity levels plus OFF that are selected with three switches marked 4, 5, and 6 on the DIP switch module. The values (1, 2, and 4) to the left of the DIP switch are assigned to each 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 indicating which of the seven sensitivity levels or OFF has been selected for the channel. 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 for each combination of switch settings. The factory default setting of these switches is switch 4 OFF, switch 5 ON, and switch 6 ON (sensitivity level 6, $-\Delta L/L = 0.02\%$).

Sensitivity Level	Industry Reference	Switch 4	Switch 5	Switch 6	-AL/L Threshold
0	OFF	OFF	OFF	OFF	N/A
1		ON	OFF	OFF	0.64%
2	Low	OFF	ON	OFF	0.32%
3		ON	ON	OFF	0.16%
4	Normal	OFF	OFF	ON	0.08%
5		ON	OFF	ON	0.04%
6*	High*	OFF*	ON*	ON*	0.02%*
7		ON	ON	ON	0.01%

* Factory default setting.

5.2 FRONT PANEL DELAY AND EXTENSION TIMING DIP SWITCHES

The Model T-210 incorporates two front panel mounted, twelve-position DIP switch modules labeled CHAN 1 and CHAN 2 that are used to set Call Delay and Call Extension times.

Extension Timing: Each detector channel can be independently set to provide an Extension Timing interval of 0 to 15.75 seconds in ¼-second increments. Call Extension settings are controlled via six DIP switches marked 1, 2, 3, 4, 5, and 6 on the DIP switch module. The values (¼, ½, 1, 2, 4, and 8) to the left of the DIP switch are assigned to each 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 six switches can combine for values from 0 to 15.75 indicating the length of the Extension Timing interval that has been selected for the channel. The following table shows the actual Extension setting for each combination of switch settings. The factory default setting of all of these switches is OFF (no Extension Time programmed).

Extension Time Setting (Seconds)	Switch 1 (1/4)	Switch 2 (1/2)	Switch 3 (1)	Switch 4 (2)	Switch 5 (4)	Switch 6 (8)	Switch Values
0	OFF	OFF	OFF	OFF	OFF	OFF	0 + 0 + 0 + 0 + 0 + 0 = 0
0.25	ON	OFF	OFF	OFF	OFF	OFF	¼ + 0 + 0 + 0 + 0 + 0 = 0.25
0.50	OFF	ON	OFF	OFF	OFF	OFF	0 + ½ + 0 + 0 + 0 + 0 = 0.50
0.75	ON	ON	OFF	OFF	OFF	OFF	¼ + ½ + 0 + 0 + 0 + 0 = 0.75
1.00	OFF	OFF	ON	OFF	OFF	OFF	0 + 0 + 1 + 0 + 0 + 0 = 1.00
1.25	ON	OFF	ON	OFF	OFF	OFF	¼ + 0 + 1 + 0 + 0 + 0 = 1.25
1.50	OFF	ON	ON	OFF	OFF	OFF	0 + ½ + 1 + 0 + 0 + 0 = 1.50
1.75	ON	ON	ON	OFF	OFF	OFF	¼ + ½ + 1 + 0 + 0 + 0 = 1.75
2.00	OFF	OFF	OFF	ON	OFF	OFF	0 + 0 + 0 + 2 + 0 + 0 = 2.00
2.25	ON	OFF	OFF	ON	OFF	OFF	¼ + 0 + 1 + 0 + 0 + 0 = 2.25
2.50	OFF	ON	OFF	ON	OFF	OFF	0 + ½ + 0 + 2 + 0 + 0 = 2.50
2.75	ON	ON	OFF	ON	OFF	OFF	¼ + ½ + 0 + 2 + 0 + 0 = 2.75
3.00	OFF	OFF	ON	ON	OFF	OFF	0 + 0 + 1 + 2 + 0 + 0 = 3.00
3.25	ON	OFF	ON	ON	OFF	OFF	¼ + 0 + 1 + 2 + 0 + 0 = 3.25
3.50	OFF	ON	ON	ON	OFF	OFF	0 + ½ + 1 + 2 + 0 + 0 = 3.50
3.75	ON	ON	ON	ON	OFF	OFF	¼ + ½ + 1 + 2 + 0 + 0 = 3.75
4.00	OFF	OFF	OFF	OFF	ON	OFF	0 + 0 + 0 + 4 + 0 + 0 = 4.00
4.25	ON	OFF	OFF	OFF	ON	OFF	¼ + 0 + 0 + 0 + 4 + 0 = 4.25
4.50	OFF	ON	OFF	OFF	ON	OFF	0 + ½ + 0 + 0 + 4 + 0 = 4.50
4.75	ON	ON	OFF	OFF	ON	OFF	¼ + ½ + 0 + 0 + 4 + 0 = 4.75
5.00	OFF	OFF	ON	OFF	ON	OFF	0 + 0 + 1 + 0 + 4 + 0 = 5.00
5.25	ON	OFF	ON	OFF	ON	OFF	¼ + 0 + 1 + 0 + 4 + 0 = 5.25
5.50	OFF	ON	ON	OFF	ON	OFF	0 + ½ + 1 + 0 + 4 + 0 = 5.50
5.75	ON	ON	ON	OFF	ON	OFF	¼ + ½ + 1 + 0 + 4 + 0 = 5.75
6.00	OFF	OFF	OFF	ON	ON	OFF	0 + 0 + 0 + 2 + 4 + 0 = 6.00
6.25	ON	OFF	OFF	ON	ON	OFF	¼ + 0 + 0 + 2 + 4 + 0 = 6.25
6.50	OFF	ON	OFF	ON	ON	OFF	0 + ½ + 0 + 2 + 4 + 0 = 6.50
6.75	ON	ON	OFF	ON	ON	OFF	¼ + ½ + 0 + 2 + 4 + 0 = 6.75
7.00	OFF	OFF	ON	ON	ON	OFF	0 + 0 + 1 + 2 + 4 + 0 = 7.00
7.25	ON	OFF	ON	ON	ON	OFF	¼ + 0 + 1 + 2 + 4 + 0 = 7.25
7.50	OFF	ON	ON	ON	ON	OFF	0 + ½ + 1 + 2 + 4 + 0 = 7.50
7.75	ON	ON	ON	ON	ON	OFF	¼ + ½ + 1 + 2 + 4 + 0 = 7.75
8.00	OFF	OFF	OFF	OFF	OFF	ON	0 + 0 + 0 + 0 + 0 + 8 = 8.00
8.25	ON	OFF	OFF	OFF	OFF	ON	¼ + 0 + 0 + 0 + 0 + 8 = 8.25
8.50	OFF	ON	OFF	OFF	OFF	ON	0 + ½ + 0 + 0 + 0 + 8 = 8.50

Extension Time Setting (Seconds)	Switch 1 (1/4)	Switch 2 (1/2)	Switch 3 (1)	Switch 4 (2)	Switch 5 (4)	Switch 6 (8)	Switch Values
8.75	ON	ON	OFF	OFF	OFF	ON	$\frac{1}{4} + \frac{1}{2} + 0 + 0 + 0 + 8 = 8.75$
9.00	OFF	OFF	ON	OFF	OFF	ON	$0 + 0 + 1 + 0 + 0 + 8 = 9.00$
9.25	ON	OFF	ON	OFF	OFF	ON	$\frac{1}{4} + 0 + 1 + 0 + 0 + 8 = 9.25$
9.50	OFF	ON	ON	OFF	OFF	ON	$0 + \frac{1}{2} + 1 + 0 + 0 + 8 = 9.50$
9.75	ON	ON	ON	OFF	OFF	ON	$\frac{1}{4} + \frac{1}{2} + 1 + 0 + 0 + 8 = 9.75$
10.00	OFF	OFF	OFF	ON	OFF	ON	$0 + 0 + 0 + 2 + 0 + 8 = 10.00$
10.25	ON	OFF	OFF	ON	OFF	ON	$\frac{1}{4} + 0 + 0 + 2 + 0 + 8 = 10.25$
10.50	OFF	ON	OFF	ON	OFF	ON	$0 + \frac{1}{2} + 0 + 2 + 0 + 8 = 10.50$
10.75	ON	ON	OFF	ON	OFF	ON	$\frac{1}{4} + \frac{1}{2} + 0 + 2 + 0 + 8 = 10.75$
11.00	OFF	OFF	ON	ON	OFF	ON	$0 + 0 + 1 + 2 + 0 + 8 = 11.00$
11.25	ON	OFF	ON	ON	OFF	ON	$\frac{1}{4} + 0 + 1 + 2 + 0 + 8 = 11.25$
11.50	OFF	ON	ON	ON	OFF	ON	$0 + \frac{1}{2} + 1 + 2 + 0 + 8 = 11.50$
11.75	ON	ON	ON	ON	OFF	ON	$\frac{1}{4} + \frac{1}{2} + 1 + 2 + 0 + 8 = 11.75$
12.00	OFF	OFF	OFF	OFF	ON	ON	$0 + 0 + 0 + 0 + 4 + 8 = 12.00$
12.25	ON	OFF	OFF	OFF	ON	ON	$\frac{1}{4} + 0 + 0 + 0 + 4 + 8 = 12.25$
12.50	OFF	ON	OFF	OFF	ON	ON	$0 + \frac{1}{2} + 0 + 0 + 4 + 8 = 12.50$
12.75	ON	ON	OFF	OFF	ON	ON	$\frac{1}{4} + 0 + 1 + 0 + 4 + 8 = 12.75$
13.00	OFF	OFF	ON	OFF	ON	ON	$0 + 0 + 1 + 0 + 4 + 8 = 13.00$
13.25	ON	OFF	ON	OFF	ON	ON	$\frac{1}{4} + 0 + 1 + 0 + 4 + 8 = 13.25$
13.50	OFF	ON	ON	OFF	ON	ON	$0 + \frac{1}{2} + 1 + 0 + 4 + 8 = 13.50$
13.75	ON	ON	ON	OFF	ON	ON	$\frac{1}{4} + \frac{1}{2} + 1 + 0 + 4 + 8 = 13.75$
14.00	OFF	OFF	OFF	ON	ON	ON	$0 + 0 + 0 + 2 + 4 + 8 = 14.00$
14.25	ON	OFF	OFF	ON	ON	ON	$\frac{1}{4} + 0 + 0 + 2 + 4 + 8 = 14.25$
14.50	OFF	ON	OFF	ON	ON	ON	$0 + \frac{1}{2} + 0 + 2 + 4 + 8 = 14.50$
14.75	ON	ON	OFF	ON	ON	ON	$\frac{1}{4} + \frac{1}{2} + 0 + 2 + 4 + 8 = 14.75$
15.00	OFF	OFF	ON	ON	ON	ON	$0 + 0 + 1 + 2 + 4 + 8 = 15.00$
15.25	ON	OFF	ON	ON	ON	ON	$\frac{1}{4} + 0 + 1 + 2 + 4 + 8 = 15.25$
15.50	OFF	ON	ON	ON	ON	ON	$0 + \frac{1}{2} + 1 + 2 + 4 + 8 = 15.50$
15.75	ON	ON	ON	ON	ON	ON	$\frac{1}{4} + \frac{1}{2} + 1 + 2 + 4 + 8 = 15.75$

Delay Timing: Each detector channel can be independently set to provide a Delay Timing interval of 0 to 63 seconds in 1-second increments. Call Delay settings are controlled via six DIP switches marked 7, 8, 9, 10, 11, and 12 on the DIP switch module. The values (1, 2, 4, 8, 16 and 32) to the left of the DIP switch are assigned to each 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 six switches can combine for values from 0 to 63 indicating the length of the Delay Timing interval that has been selected for the channel. The following table shows the actual Delay Time setting for each combination of switch settings. The factory default setting of all of these switches is OFF (no Delay Time programmed).

Delay Time Setting (Seconds)	Switch 7 (1)	Switch 8 (2)	Switch 9 (4)	Switch 10 (8)	Switch 11 (16)	Switch 12 (32)	Switch Values
0	OFF	OFF	OFF	OFF	OFF	OFF	$0 + 0 + 0 + 0 + 0 + 0 = 0$
1	ON	OFF	OFF	OFF	OFF	OFF	$1 + 0 + 0 + 0 + 0 + 0 = 1$
2	OFF	ON	OFF	OFF	OFF	OFF	$0 + 2 + 0 + 0 + 0 + 0 = 2$
3	ON	ON	OFF	OFF	OFF	OFF	$1 + 2 + 0 + 0 + 0 + 0 = 3$
4	OFF	OFF	ON	OFF	OFF	OFF	$0 + 0 + 4 + 0 + 0 + 0 = 4$
5	ON	OFF	ON	OFF	OFF	OFF	$1 + 0 + 4 + 0 + 0 + 0 = 5$
6	OFF	ON	ON	OFF	OFF	OFF	$0 + 2 + 4 + 0 + 0 + 0 = 6$
7	ON	ON	ON	OFF	OFF	OFF	$1 + 2 + 4 + 0 + 0 + 0 = 7$
8	OFF	OFF	OFF	ON	OFF	OFF	$0 + 0 + 0 + 8 + 0 + 0 = 8$
9	ON	OFF	OFF	ON	OFF	OFF	$1 + 0 + 0 + 8 + 0 + 0 = 9$
10	OFF	ON	OFF	ON	OFF	OFF	$0 + 2 + 0 + 8 + 0 + 0 = 10$
11	ON	ON	OFF	ON	OFF	OFF	$1 + 2 + 0 + 8 + 0 + 0 = 11$
12	OFF	OFF	ON	ON	OFF	OFF	$0 + 0 + 4 + 8 + 0 + 0 = 12$
13	ON	OFF	ON	ON	OFF	OFF	$1 + 0 + 4 + 8 + 0 + 0 = 13$
14	OFF	ON	ON	ON	OFF	OFF	$0 + 2 + 4 + 8 + 0 + 0 = 14$
15	ON	ON	ON	ON	OFF	OFF	$1 + 2 + 4 + 8 + 0 + 0 = 15$
16	OFF	OFF	OFF	OFF	ON	OFF	$0 + 0 + 0 + 0 + 16 + 0 = 16$
17	ON	OFF	OFF	OFF	ON	OFF	$1 + 0 + 0 + 0 + 16 + 0 = 17$

Delay Time Setting (Seconds)	Switch7 (1)	Switch8 (2)	Switch9 (4)	Switch 10(8)	Switch 11(16)	Switch 12(32)	Switch Values
18	OFF	ON	OFF	OFF	ON	OFF	0+2+0+0+16+0=18
19	ON	ON	OFF	OFF	ON	OFF	1+2+0+0+16+0=19
20	OFF	OFF	ON	OFF	ON	OFF	0+0+4+0+16+0=20
21	ON	OFF	ON	OFF	ON	OFF	1+0+4+0+16+0=21
22	OFF	ON	ON	OFF	ON	OFF	0+2+4+0+16+0=22
23	ON	ON	ON	OFF	ON	OFF	1+2+4+0+16+0=23
24	OFF	OFF	OFF	ON	ON	OFF	0+0+0+8+16+0=24
25	ON	OFF	OFF	ON	ON	OFF	1+0+0+8+16+0=25
26	OFF	ON	OFF	ON	ON	OFF	0+2+0+8+16+0=26
27	ON	ON	OFF	ON	ON	OFF	1+2+0+8+16+0=27
28	OFF	OFF	ON	ON	ON	OFF	0+0+4+8+16+0=28
29	ON	OFF	ON	ON	ON	OFF	1+0+4+8+16+0=29
30	OFF	ON	ON	ON	ON	OFF	0+2+4+8+16+0=30
31	ON	ON	ON	ON	ON	OFF	1+2+4+8+16+0=31
32	OFF	OFF	OFF	OFF	OFF	ON	0+0+0+0+0+32=32
33	ON	OFF	OFF	OFF	OFF	ON	1+0+0+0+0+32=33
34	OFF	ON	OFF	OFF	OFF	ON	0+2+0+0+0+32=34
35	ON	ON	OFF	OFF	OFF	ON	1+2+0+0+0+32=35
36	OFF	OFF	ON	OFF	OFF	ON	0+0+4+0+0+32=36
37	ON	OFF	ON	OFF	OFF	ON	1+0+4+0+0+32=37
38	OFF	ON	ON	OFF	OFF	ON	0+2+4+0+0+32=38
39	ON	ON	ON	OFF	OFF	ON	1+2+4+0+0+32=39
40	OFF	OFF	OFF	ON	OFF	ON	0+0+0+8+0+32=40
41	ON	OFF	OFF	ON	OFF	ON	1+0+0+8+0+32=41
42	OFF	ON	OFF	ON	OFF	ON	0+2+0+8+0+32=42
43	ON	ON	OFF	ON	OFF	ON	1+2+0+8+0+32=43
44	OFF	OFF	ON	ON	OFF	ON	0+0+4+8+0+32=44
45	ON	OFF	ON	ON	OFF	ON	1+0+4+8+0+32=45
46	OFF	ON	ON	ON	OFF	ON	0+2+4+8+0+32=46
47	ON	ON	ON	ON	OFF	ON	1+2+4+8+0+32=47
48	OFF	OFF	OFF	OFF	ON	ON	0+0+0+0+16+32=48
49	ON	OFF	OFF	OFF	ON	ON	1+0+0+0+16+32=49
50	OFF	ON	OFF	OFF	ON	ON	0+2+0+0+16+32=50
51	ON	ON	OFF	OFF	ON	ON	1+2+0+0+16+32=51
52	OFF	OFF	ON	OFF	ON	ON	0+0+4+0+16+32=52
53	ON	OFF	ON	OFF	ON	ON	1+0+4+0+16+32=53
54	OFF	ON	ON	OFF	ON	ON	0+2+4+0+16+32=54
55	ON	ON	ON	OFF	ON	ON	1+2+4+0+16+32=55
56	OFF	OFF	OFF	ON	ON	ON	0+0+0+8+16+32=56
57	ON	OFF	OFF	ON	ON	ON	1+0+0+8+16+32=57
58	OFF	ON	OFF	ON	ON	ON	0+2+0+8+16+32=58
59	ON	ON	OFF	ON	ON	ON	1+2+0+8+16+32=59
60	OFF	OFF	ON	ON	ON	ON	0+0+4+8+16+32=60
61	ON	OFF	ON	ON	ON	ON	1+0+4+8+16+32=61
62	OFF	ON	ON	ON	ON	ON	0+2+4+8+16+32=62
63	ON	ON	ON	ON	ON	ON	1+2+4+8+16+32=63

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

The push button 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 push button. The first time the push button is pressed, a short (50 millisecond) audible signal confirms the activation of the feature for Channel 1. The second time the push button 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 push button 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.

5.4 FRONT PANEL MOUNTED PUSHBUTTON – DETECTOR RESET

The push button on the front panel labeled **RESET** is used to reset the detector.

5.5 PC BOARD MOUNTED JUMPER – TEST MODE

Test Mode uses the microcontroller to verify the proper operation of the detector's controls and indicators (switches and LEDs). When connected to loops of the appropriate inductance (100 microhenries), each channel's loop oscillator circuit can also be tested to verify the correct frequency range in each of the four frequency selections. Test Mode is selected by placing a shorting jumper (shunt) across the PC Board mounted two-pin header labeled **TEST**. Refer to Section 8.5 for a complete explanation of Test Mode operation.

5.6 LOOP FAIL INDICATIONS

The Detect / Fail LED for each channel indicates loop failure problems according to the following table. The Detect / Fail LED is illuminated in a red state to provide an indication of either a current or prior out of tolerance (loop failure) condition. 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. If the loop self-heals, the channel 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 channel has experienced a prior loop failure condition.

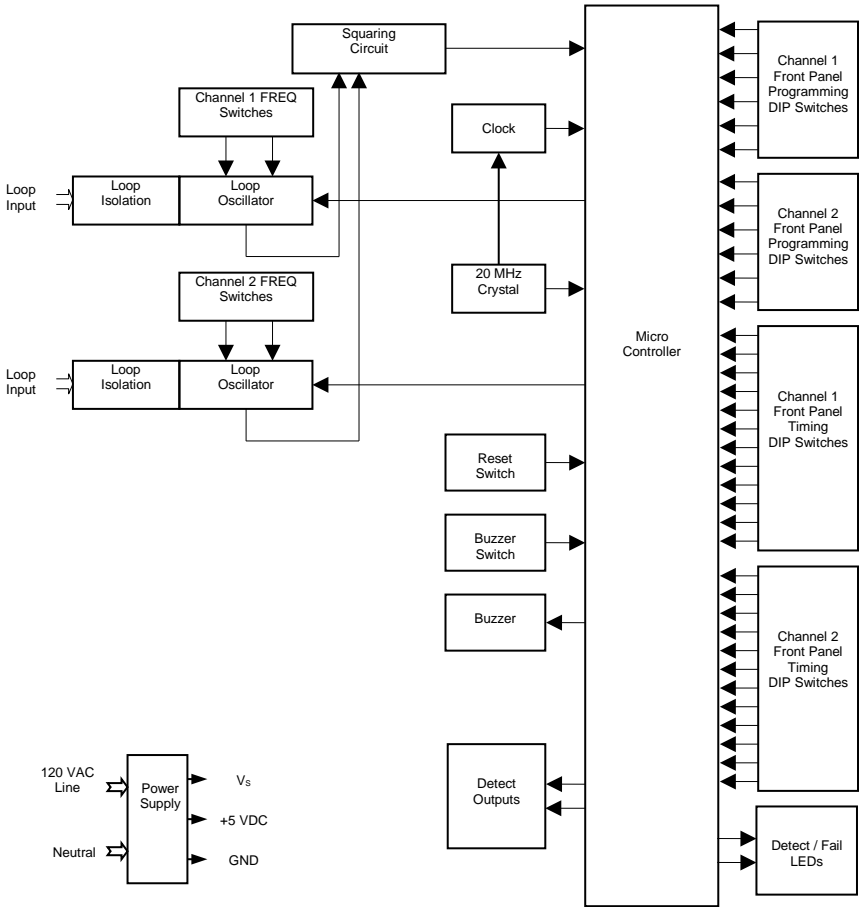
Detect / Fail LED	Meaning
OFF	No Loop Failure
Solid ON (Red)	Open Loop Failure Or Inductance change condition of greater than +25% exists
One Hz flash rate (Red) (50% Duty Cycle)	Shorted Loop Failure Or Inductance change condition of greater than -25% exists
Three 50 ms (Red) flashes per second	Loop Failure condition occurred but no longer exists

5.7 RESETTING THE DETECTOR

Changing the position of any of an individual channel's front panel mounted programming DIP switches (except the Frequency switches) resets the channel. Changes made to any of the channel's Delay and/or Extension Timing DIP switches do not reset the channel.

The detector is reset by pressing the front panel mounted reset push button or by the return of power after a power loss.

Section 6 Block Diagram



Section 7 Theory of Operation

The Reno A & E Model T-210 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 zones. 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 opened or shorted loop circuit.

The detector scans the loop / lead-in circuits connected to each detector channel. The scanning method alternates the on and off cycle of each channel's loop circuit such that only one channel's loop circuit is active at a given time. 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 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 for 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 $\pm 25\%$, the channel will immediately enter the Fail-Safe mode of operation. Fail-Safe operation generates a continuous call output in Presence Mode or Pulse Mode. The Detect / Fail LED will turn ON (red) or flash (red) at a one Hz rate and remain on or continue flashing for 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 begin to display a pattern 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.

The detector is designed to operate from A.C. power sources providing 120 VAC. On board regulators provide regulated voltages so that the detector can safely operate over the full input voltage range of 89 VAC to 135 VAC. The unit is also provided with an external reset capability. When the front panel mounted reset button is pressed, all detector channels are immediately reset. Changing any front panel programming DIP switch (except the frequency DIP switches) resets the associated channel.

Operating parameters that can be selected by means of the front panel DIP switches are Loop Frequency, Presence / Pulse Mode, Sensitivity, Delay Timing, and Extension Timing. A front panel mounted push button is used for activation of an audible detect signal. 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 either a fail-safe optically isolated transistor or a mechanical relay. 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 connected to 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.

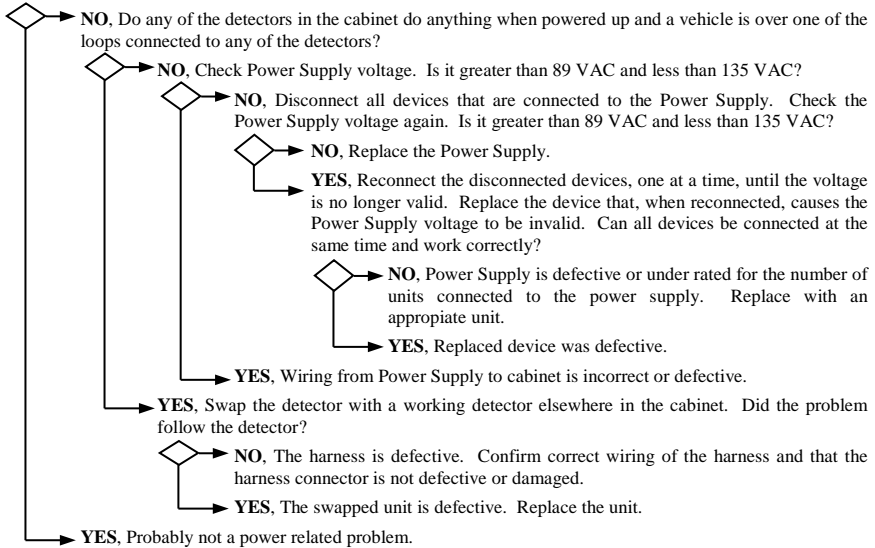
Section 8 Maintenance and Troubleshooting

The Reno A & E Model T-210 Detector requires no maintenance. If you are having problems with your Model T-210 detector, use the troubleshooting chart below to help determine the cause of the problem.

Symptom	Where To Start
No LEDs lit and detector does not respond to traffic.	See Troubleshooting Power Problems . Check for sensitivity set extremely low (0 to 2).
LOOP FAIL indication (LED ON Red or flashing Red at a one Hz rate). Previous LOOP FAIL indication	See Troubleshooting Loop Fail Problems .
(LED flashing three times per second Red) and detector appears to be working correctly.	See Troubleshooting Intermittent Loop Fail Problems .
Detector intermittently stays in the Call state (LED ON Green).	See Troubleshooting Intermittent Detector Lock Ups .

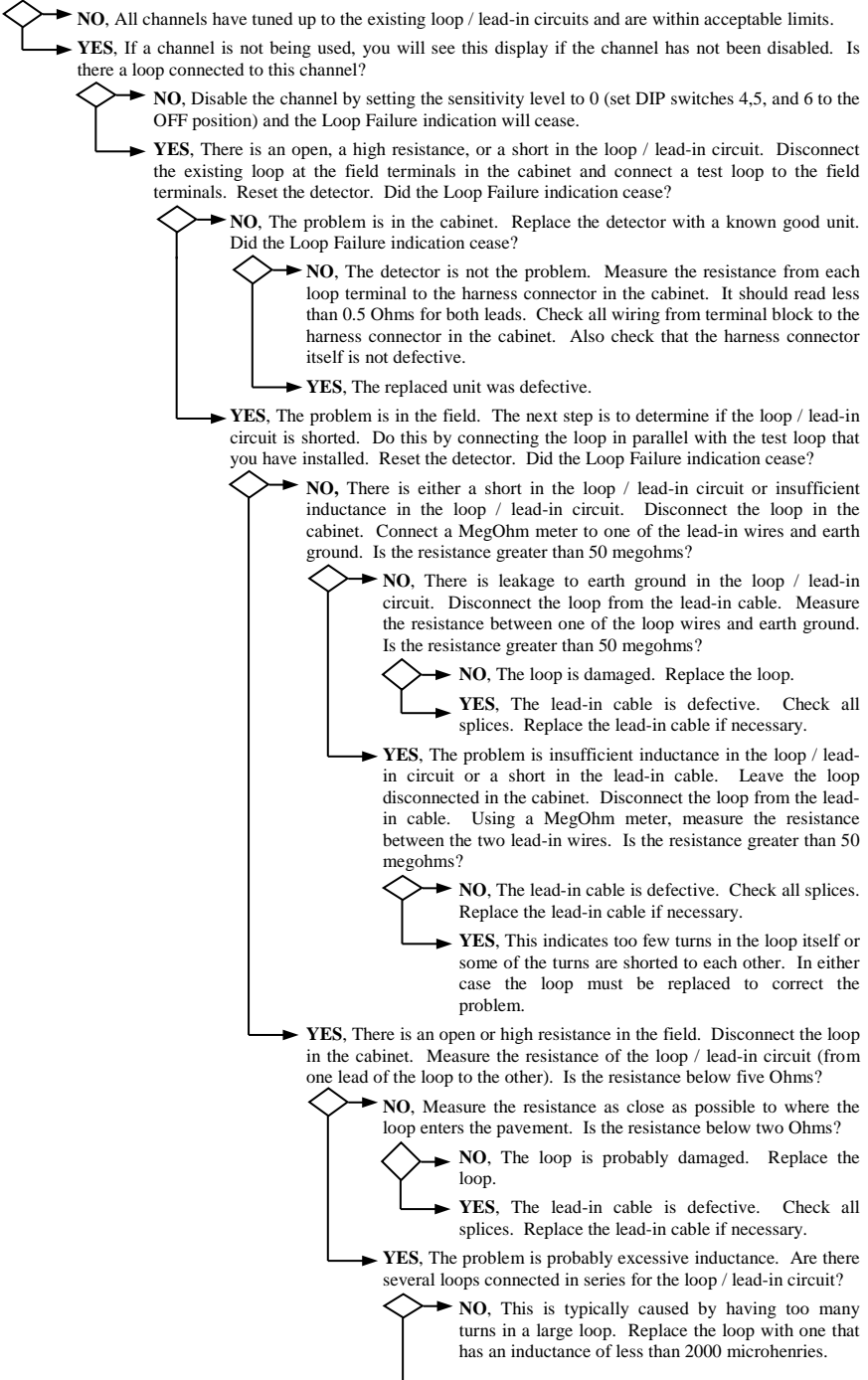
8.1 TROUBLESHOOTING POWER PROBLEMS

Do any of the LEDs turn ON (Green) when the detector is powered up and a vehicle is over one of the loops connected to the detector?



8.2 TROUBLESHOOTING LOOP FAIL PROBLEMS

Is one of the two front panel LEDs showing a Loop Failure indication (ON Red or one Hz flash rate Red)?



- **YES**. If possible, connecting each loop to its own detector is preferred. Or try a parallel wiring arrangement for the loops if separate detection channels are not possible.

8.3 TROUBLESHOOTING INTERMITTENT LOOP FAIL PROBLEMS

Intermittent Loop Fail problems tend to be associated with bad splices in the loop / lead-in circuit, shorts in the loop / lead-in circuit, shorts to earth ground in the loop / lead-in circuit, or loose connections or bad solder joints in the signal cabinet. If you have any splices that are not soldered and sealed with an adhesive heat shrink or epoxy resin, replace the splice with one that is. Using a MegOhm meter, measure the resistance from one of the loop wires to earth ground. It should be greater than 50 megohms. Inspect the loop. Look for exposed wires or debris pressed into the saw cut. Tighten all screw terminals in the signal cabinet that the loop circuit uses. Check solder joints in the loop circuit, especially on the rack itself. Disconnect and reconnect any connector used in the loop circuit and check for loose pins and sockets in these connectors. If your cabinet has lightning or surge suppression devices on the loop inputs in the cabinet, remove or replace them. Check for places in the field where the loop wire or lead-in cable may be pinched or chaffed. Look for wires pinched under junction box covers and where the wire enters a conduit, especially where the loop wire leaves the saw cut and enters a conduit. After checking all of the above items, you could swap out the detector but this type of failure is rarely ever related to the detector.

8.4 TROUBLESHOOTING INTERMITTENT DETECTOR LOCK-UPS

Problems of this type tend to be difficult to isolate due to the many possible causes and the short duration of the symptom (usually less than 30 minutes). If the problem occurs more frequently in the morning or when raining, suspect a short to earth ground in the loop / lead-in circuit. This can usually be verified by testing with a MegOhm meter, but not always. Vibration can also be a possible cause. Loop wires may be moving slightly in a conduit due to vibrations from truck traffic. Utility lids in the street near the loop may also be a source of problems. Ensure that lids near a loop are bolted down so that they cannot move. Check that each set of loop wires is twisted together in any pull boxes and that lengths are not excessive. Inspect the loop. Look for exposed wires or debris pressed into the saw cut. Check for places in the field where the loop wire or lead-in cable may be pinched or chaffed. Look for wires pinched under junction box covers and where the wire enters a conduit, especially where the loop wire leaves the saw cut and enters a conduit. **If your cabinet has lightning or surge suppression devices on the loop inputs in the cabinet, remove or replace them.** If you have any splices that are not soldered and sealed with an adhesive heat shrink or epoxy resin, replace the splice with one that is. Solder all crimp connections in the loop circuit. Tighten all screw terminals in the signal cabinet that the loop circuit uses. Check solder joints in the loop circuit, especially on the harness itself. Disconnect and reconnect any connector used in the loop circuit and check for loose pins and sockets in these connectors.

8.5 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 (Programming DIP switches):

- STEP 1.** Remove power from the detector.
- STEP 2.** Set all front panel Channel 1 Programming DIP switches (S1) to the **OFF** position.
- STEP 3.** Set all front panel Channel 2 Programming DIP switches (S4) to the **OFF** position.
- STEP 4.** Set all front panel Channel 1 Delay / Extension DIP switches (S5) to the **OFF** position.
- STEP 5.** Set all front panel Channel 2 Delay / Extension DIP switches (S6) to the **OFF** position.
- STEP 6.** Install a two-pin shorting jumper (shunt) to the PC Board mounted header labeled **TEST** (JP1) and apply power. The LED indicators should be OFF, all detect outputs should be OFF. **NOTE: To test the frequency range the detector 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 7.** Individually, turn ON switches 6, 5, 4, and 3 of the Channel 1 Programming DIP switch. Turn OFF each switch after verifying the results indicated in the table below.

Switch Label	Switch #	LED Indications and Outputs
SENSE LEVEL 4	6	CHANNEL 1 DETECT / FAIL LED ILLUMINATED - GREEN
SENSE LEVEL 2	5	CHANNEL 1 DETECT / FAIL LED ILLUMINATED - RED
SENSE LEVEL 1	4	CHANNEL 1 DETECT / FAIL LED ILLUMINATED - GREEN
PRES PULS	3	CHANNEL 1 DETECT / FAIL LED ILLUMINATED - RED

STEP 8. Individually, turn ON switches 6, 5, 4, and 3 of the Channel 2 Programming DIP switch. Turn OFF each switch after verifying the results indicated in the table below.

Switch Label	Switch #	LED Indications and Outputs
SENSE LEVEL 4	6	CHANNEL 2 DETECT / FAIL LED ILLUMINATED - GREEN
SENSE LEVEL 2	5	CHANNEL 2 DETECT / FAIL LED ILLUMINATED - RED
SENSE LEVEL 1	4	CHANNEL 2 DETECT / FAIL LED ILLUMINATED - GREEN
PRES PULS	3	CHANNEL 2 DETECT / FAIL LED ILLUMINATED - RED

STEP 9. Remove power from the detector and remove the two-pin shorting jumper from the **TEST** header.

Test Procedure (Frequency DIP switches):

- STEP 1.** Remove power from the detector.
STEP 2. Set all front panel Channel 1 Programming DIP switches (S1) to the **OFF** position.
STEP 3. Set all front panel Channel 2 Programming DIP switches (S4) to the **OFF** position.
STEP 4. Set all front panel Channel 1 Delay / Extension DIP switches (S5) to the **OFF** position.
STEP 5. Set all front panel Channel 2 Delay / Extension DIP switches (S6) to the **OFF** position.
STEP 6. Install a two-pin shorting jumper (shunt) to the PC Board mounted header labeled **TEST** (JP1) and apply power. The LED indicators should be OFF, all detect outputs should be OFF. **NOTE: To test the frequency range the detector 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 7. Individually, turn ON the two Channel 1 Frequency DIP switches (switches 2 and 1 of the Channel 1 Programming DIP switch). Turn OFF each switch after verifying the results indicated in the table below.

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

STEP 8. Individually, turn ON the two Channel 2 Frequency DIP switches (switches 2 and 1 of the Channel 2 Programming DIP switch). Turn OFF each switch after verifying the results indicated in the table below.

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

STEP 9. Remove power from the detector and remove the two-pin shorting jumper from the **TEST** header.

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 (Delay / Extension DIP switches):

- STEP 1.** Remove power from the detector.
STEP 2. Set all front panel Channel 1 Programming DIP switches (S1) to the **OFF** position.
STEP 3. Set all front panel Channel 2 Programming DIP switches (S4) to the **OFF** position.
STEP 4. Set all front panel Channel 1 Delay / Extension DIP switches (S5) to the **OFF** position.
STEP 5. Set all front panel Channel 2 Delay / Extension DIP switches (S6) to the **OFF** position.
STEP 6. Install a two-pin shorting jumper (shunt) to the PC Board mounted header labeled **TEST** (JP1) and apply power. The LED indicators should be OFF, all detect outputs should be OFF. **NOTE: To test the frequency range the detector 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 7. Individually, turn ON switches 12 through 1 of the Channel 1 Delay / Extension DIP switch. Turn OFF each switch after verifying the results indicated in the table below.

Switch Label	Switch #	LED Indications and Outputs
DELAY 32	12	CHANNEL 1 DETECT / FAIL LED ILLUMINATED - GREEN
DELAY 16	11	CHANNEL 1 DETECT / FAIL LED ILLUMINATED - RED
DELAY 8	10	CHANNEL 1 DETECT / FAIL LED ILLUMINATED - GREEN
DELAY 4	9	CHANNEL 1 DETECT / FAIL LED ILLUMINATED - RED
DELAY 2	8	CHANNEL 1 DETECT / FAIL LED ILLUMINATED - GREEN
DELAY 1	7	CHANNEL 1 DETECT / FAIL LED ILLUMINATED - RED
EXTEND 8	6	CHANNEL 1 DETECT / FAIL LED ILLUMINATED - GREEN
EXTEND 4	5	CHANNEL 1 DETECT / FAIL LED ILLUMINATED - RED
EXTEND 2	4	CHANNEL 1 DETECT / FAIL LED ILLUMINATED - GREEN
EXTEND 1	3	CHANNEL 1 DETECT / FAIL LED ILLUMINATED - RED
EXTEND 1/2	2	CHANNEL 1 DETECT / FAIL LED ILLUMINATED - GREEN
EXTEND 1/4	1	CHANNEL 1 DETECT / FAIL LED ILLUMINATED - RED

STEP 8. Individually, turn ON switches 12 through 1 of the Channel 2 Delay / Extension DIP switch. Turn OFF each switch after verifying the results indicated in the table below.

Switch Label	Switch #	LED Indications and Outputs
DELAY 32	12	CHANNEL 2 DETECT / FAIL LED ILLUMINATED - GREEN
DELAY 16	11	CHANNEL 2 DETECT / FAIL LED ILLUMINATED - RED
DELAY 8	10	CHANNEL 2 DETECT / FAIL LED ILLUMINATED - GREEN
DELAY 4	9	CHANNEL 2 DETECT / FAIL LED ILLUMINATED - RED
DELAY 2	8	CHANNEL 2 DETECT / FAIL LED ILLUMINATED - GREEN
DELAY 1	7	CHANNEL 2 DETECT / FAIL LED ILLUMINATED - RED
EXTEND 8	6	CHANNEL 2 DETECT / FAIL LED ILLUMINATED - GREEN
EXTEND 4	5	CHANNEL 2 DETECT / FAIL LED ILLUMINATED - RED
EXTEND 2	4	CHANNEL 2 DETECT / FAIL LED ILLUMINATED - GREEN
EXTEND 1	3	CHANNEL 2 DETECT / FAIL LED ILLUMINATED - RED
EXTEND 1/2	2	CHANNEL 2 DETECT / FAIL LED ILLUMINATED - GREEN
EXTEND 1/4	1	CHANNEL 2 DETECT / FAIL LED ILLUMINATED - RED

STEP 9. Remove power from the detector and remove the two-pin shorting jumper from the **TEST** header.

Test Procedure (Front Panel Buzzer switch):

- STEP 1.** Remove power from the detector.
- STEP 2.** Refer to the table in Section 3.5 and set all front panel Channel 1 and Channel 2 Programming DIP switches (S1 and S4) to their default positions.
- STEP 3.** Set all front panel Channel 1 and Channel 2 Delay / Extension DIP switches (S5 and S6) to the **OFF** position.
- STEP 4.** Apply power. The LED indicators should be OFF, all detect outputs should be OFF. **NOTE: To test the frequency range the detector 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 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	<ul style="list-style-type: none"> • CHANNEL 1 DETECT / FAIL LED ILLUMINATED - ORANGE • BUZZER SOUNDS
REMOVE CALL CHANNEL 1	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • CHANNEL 2 DETECT / FAIL LED ILLUMINATED - ORANGE • BUZZER SOUNDS
REMOVE CALL CHANNEL 2	<ul style="list-style-type: none"> • 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 (Front Panel Reset switch):

- STEP 1.** Remove power from the detector.
- STEP 2.** Refer to the table in Section 3.5 and set all front panel Channel 1 and Channel 2 Programming DIP switches (S1 and S4) to their default positions.

- STEP 3.** Set all front panel Channel 1 and Channel 2 Delay / Extension DIP switches (S5 and S6) to the **OFF** position.
- STEP 4.** Apply power. The LED indicators should be OFF, all detect outputs should be OFF. **NOTE: To test the frequency range the detector 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 5.** Perform the actions and verify the results indicated in the table below. **NOTE: Unless otherwise noted, references to switches, buttons, or inputs in the table correspond to labels on test equipment supplied by Reno A & E.**

Switch / Button / Input	Action	LED Indications and Outputs
DETECTOR <i>RESET</i> BUTTON	PRESS AND HOLD	<ul style="list-style-type: none"> • DETECTOR CHANNEL 1 OUTPUT ON • TEST BOX CHANNEL 1 DETECT LED ON • DETECTOR CHANNEL 2 OUTPUT ON • TEST BOX CHANNEL 2 DETECT LED ON
DETECTOR <i>RESET</i> BUTTON	RELEASE	<ul style="list-style-type: none"> • DETECTOR CHANNEL 1 OUTPUT OFF • TEST BOX CHANNEL 1 DETECT LED OFF • DETECTOR CHANNEL 2 OUTPUT OFF • TEST BOX CHANNEL 2 DETECT LED OFF

STEP 6. Remove power from the detector.

8.6 THINGS TO KNOW ABOUT LOOPS

Always use a wire with cross-linked Polyethylene insulation (insulation type XLPE) for loop wire.

Typical sensing height is 2/3 of the shortest leg of a loop. Therefore, a 6' x 6' loop will have a detection height of 4'.

The inductance of a conventional four-sided loop can be estimated using the formula:

$$L = P \times (T^2 + T) / 4$$

Where: L = Loop Inductance in microhenries
P = Loop Perimeter in feet
T = Number of Turns of Wire.

Therefore, a 6' by 6' loop with 3 turns would have an inductance of:

$$\begin{aligned} L &= (6 + 6 + 6 + 6) \times (3^2 + 3) / 4 \\ L &= 24 \times (9 + 3) / 4 \\ L &= 24 \times 12 / 4 \\ L &= 24 \times 3 \\ L &= 72 \text{ microhenries.} \end{aligned}$$

The inductance of a Quadrupole™ loop can be estimated using the formula:

$$L = [P \times (T_{OL}^2 + T_{OL}) / 4] + [CL \times (T_{CL}^2 + T_{CL}) / 4]$$

Where: L = Loop Inductance in microhenries
P = Loop Perimeter in feet
T_{OL} = Number of Turns of Wire (Outer Legs)
T_{CL} = Number of Turns of Wire (Center Legs)
CL = Length of Center Leg in feet.

Therefore, a 6' by 50' loop with a 2-4-2 configuration would have an inductance of:

$$\begin{aligned} L &= [(6 + 50 + 6 + 50) \times (2^2 + 2) / 4] + [50 \times (4^2 + 4) / 4] \\ L &= [112 \times (4 + 2) / 4] + [50 \times (16 + 4) / 4] \\ L &= (112 \times 6 / 4) + (50 \times 20 / 4) \\ L &= (112 \times 1.5) + (50 \times 5) \\ L &= 168 + 250 \\ L &= 418 \text{ microhenries.} \end{aligned}$$

Loop Feeder cable typically adds 0.22 microhenries of inductance per foot of cable.

Total inductance of loops connected in series:

$$L_{TOTAL} = L_1 + L_2 + L_3 + \dots + L_N.$$

Total inductance of loops connected in parallel:

$$L_{TOTAL} = 1 / [(1 / L_1) + (1 / L_2) + (1 / L_3) + \dots + (1 / L_N)].$$