Standard Interconnect for Traffic Signal Preemption at Railroad Crossings

DIVISION OF TRAFFIC OPERATIONS
OFFICE OF SYSTEM DEVELOPMENT
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Version 1.09
12/07/2021

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1.0 Legacy Design

Caltrans currently uses a simple 2-wire circuit for preempting traffic signals at railroad crossings (legacy design). This 2-wire system incorporates a normally closed circuit, allowing the traffic signal to perform preemption operation. Traffic signal preemption routines are handled by Caltrans Traffic Signal Control Program. Although the legacy design shown in **Figure 1** has worked well for decades, the California Public Utilities Commission (CPUC) identified safety enhancements requiring additional hardware and software modifications.

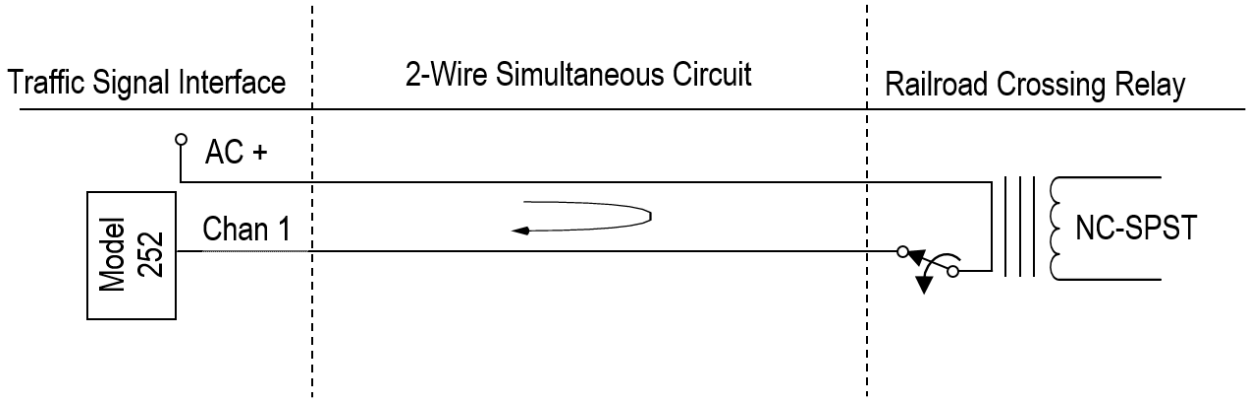

Figure 1: Legacy Interconnect Preemption Circuit (NORMAL state)

2.0 Objectives

The objective of the new design is to maintain the simplicity of the legacy design but provide additional functionality as described in this standard. The new design provides the following features:

Supervised Circuits: An additional wire provides a way to detect circuit faults (a short circuit or a break in the wire). As indicated in the American Railway Engineering and Maintenance-of-Way Association (AREMA) research paper, reference, No.1, it is important to detect a potential short in the interconnection circuit between the traffic signal and railroad equipment. It is also important to detect the difference between a railroad preemption notification and a break in the wire.

Simultaneous (SIM) and Advance (ADV) Preemption: Two supervised circuits are utilized to transition the traffic signal into preemption. The use of these inputs (SIM and ADV) will vary depending on the preemption timing.

Advance Pedestrian Preemption (APP): A circuit utilized to obtain early notification of an approaching train, prior to advance preemption or simultaneous preemption. This circuit, allows the traffic signal to serve pedestrians upon the approach of a train.

Gate Down/Island (GD/ISL): A circuit utilized to monitor gate arm position and presence of the train at the crossing. This will remain de-energized until either the gate arm reaches horizontal or the train reaches the crossing. With this circuit, if the gate arm has not reached horizontal position, the traffic signal would typically continue to provide a green for track clearance until the train reaches the crossing.

Traffic Signal Health Status: A circuit that provides the health status of the traffic signal to the railroad equipment.

3.0 Standard Interconnect for Traffic Signal Preemption at Railroad Crossings

This Standard Interconnect for Traffic Signal Preemption at Railroad Crossings provides supervised simultaneous preemption, supervised advance preemption, advance pedestrian preemption, gate down/island as shown in **Figure 2**, and traffic signal health status (HS) as shown in **Figure 5.**

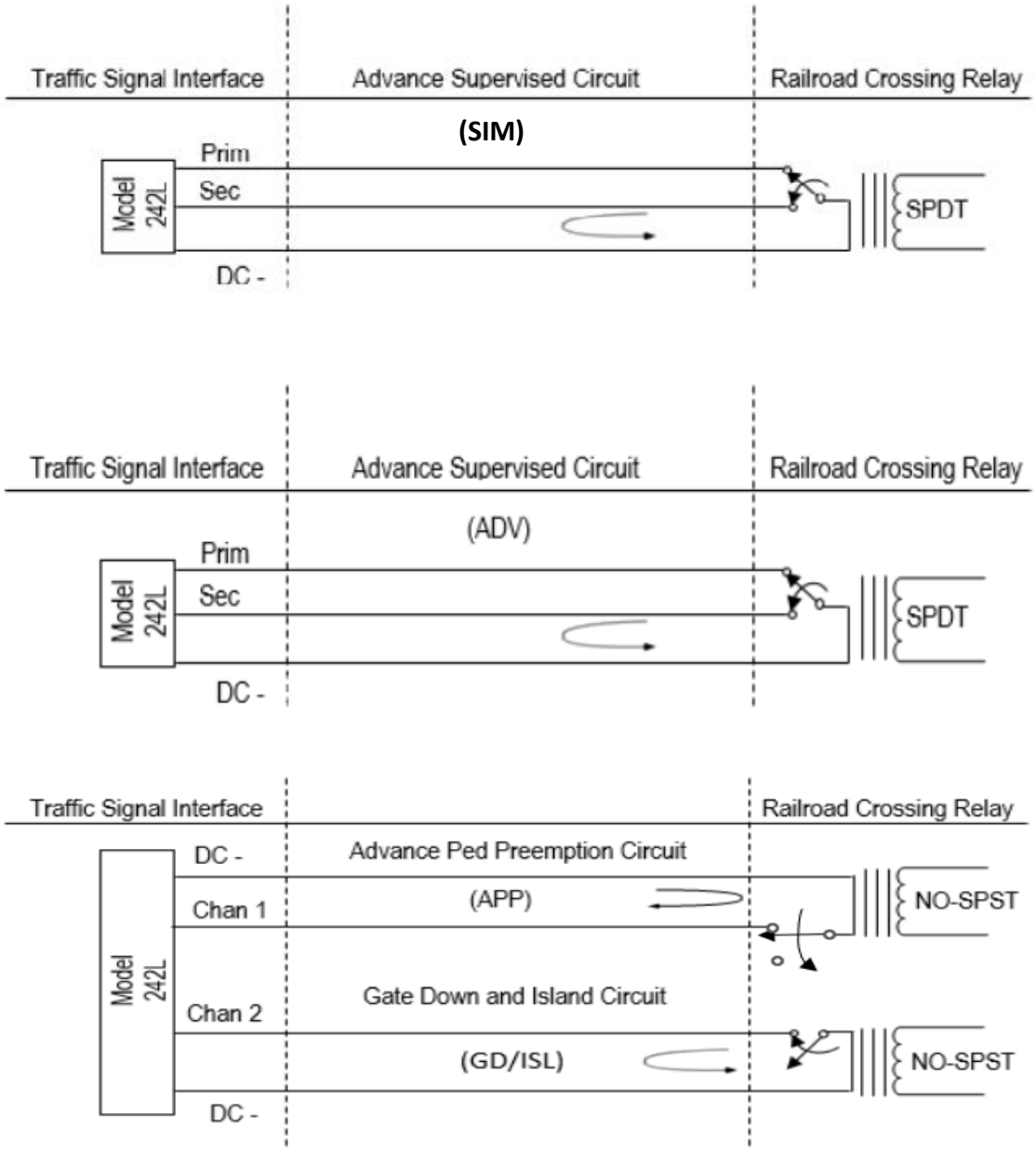

Figure 2: Interconnect using three Model 242L DC isolator modules (NORMAL state)

4.0 Simultaneous (SIM) and Advance (ADV) Preemption Circuits

Simultaneous Preemption (SIM) and Advance Preemption (ADV)

The Simultaneous Preemption and Advance Preemption circuits (both shown in **Figure 2**) are used to notify the traffic signal of an approaching train. Upon notification, the traffic signal transitions from normal operation to preemption operation. The use of these inputs (SIM and ADV) will vary depending on the preemption timing.

SIM and ADV are both implemented as supervised circuits.

Supervised Circuit Design

Implementation of a supervised circuit such as shown in **Figure 3** allows the traffic signal to continuously monitor the condition of the supervised circuit and respond to circuit fault conditions.

In the legacy standard, the preemption circuit shown in **Figure 1** will de-energize when a train approaches the crossing. This does not distinguish between an open circuit and a preemption request. For example, a break in the circuit will transition the traffic signal to preemption and remain in preemption until the circuit is restored.

Another type of fault occurs if the circuit is not de-energized upon a preemption request. Under that condition, the traffic signal will not transition into preemption during the approach of a train. This condition can occur, even if the railroad relay opens properly, but the circuit remains energized due to a short circuit. A similar condition could occur if the 252 AC isolator module were removed from the traffic signal input file. The legacy preemption circuit logic is shown in **Table 1.**

Legacy Preemption Circuit Logic	
Model 252 Input	**Traffic Signal Operation**
High	NORMAL
Low	PREEMPT

Table 1: Truth Table for Legacy Preemption Circuit Logic

The supervised circuit design, in this standard, allows the traffic signal to identify the conditions above as fault conditions. The traffic signal monitors the state of primary and secondary inputs, in the form of an exclusive-or (XOR) truth-table, as shown in **Table 2**. A short circuit or a break in the wire will result in a fault condition, which will put the traffic signal into all-red-flash.

Supervised Preemption Circuit Logic		
Model 242L Input		**Traffic Signal Operation**
Primary	Secondary	
High	Low	NORMAL
Low	High	PREEMPT
High	High	FAULT
Low	Low	FAULT

Table 2: Truth Table for Supervised Preemption Circuit Logic

As shown in **Table 2**, for each supervised circuit, the primary input is energized, while the secondary input is de-energized (NORMAL state). During preemption, the primary input becomes de-energized and the secondary input becomes energized (PREEMPT state). When the primary and secondary inputs are either both high or both low, the supervised circuit is in a fault condition (one of the FAULT states), which puts the traffic signal into all-red flash operation.

When a short in the circuit is introduced, the supervised circuit, in combination with the DC isolator logic, detects it as a circuit "FAULT" and puts the traffic signal into all-red-flash. This functionality is accomplished by utilizing a single relay at the railroad side and two inputs at the traffic signal as shown in Figure 3.

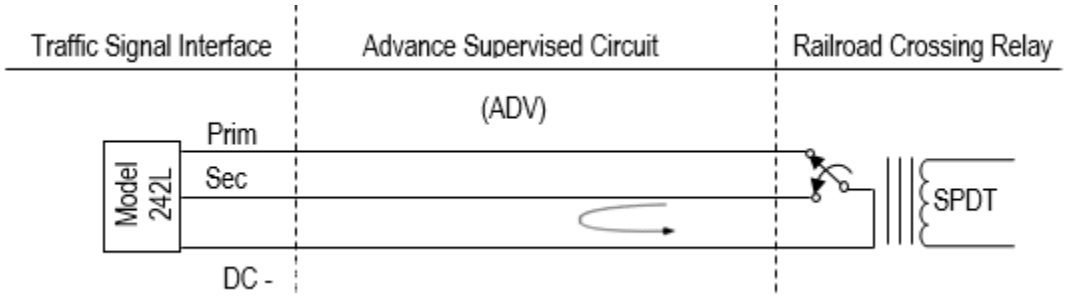

Figure 3: Example of a Supervised Circuit

5.0 Advance Pedestrian Preemption (APP) Notification Circuit

The Advance Pedestrian Preemption Notification circuit is as shown in **Figure 4**. The purpose of the circuit is to provide early notification of an approaching train, prior to advance or simultaneous preemption.

This early notification may allow the traffic signal to more smoothly transition from normal operation to railroad preemption, such as to allow for pedestrian clearance.

6.0 Gate Down/Island (GD/ISL) Circuit

The Gate Down/Island circuit as shown in **Figure 4** is a normally open circuit. The purpose of the circuit is to monitor both the gate arm position and presence of the train at the crossing. This circuit remains de-energized until either the gate arm reaches horizontal position, or the train reaches the crossing.

If the gate arm does not reach horizontal position, the traffic signal continues to provide a green for track clearance, until the train reaches the crossing (occupies the island circuit).

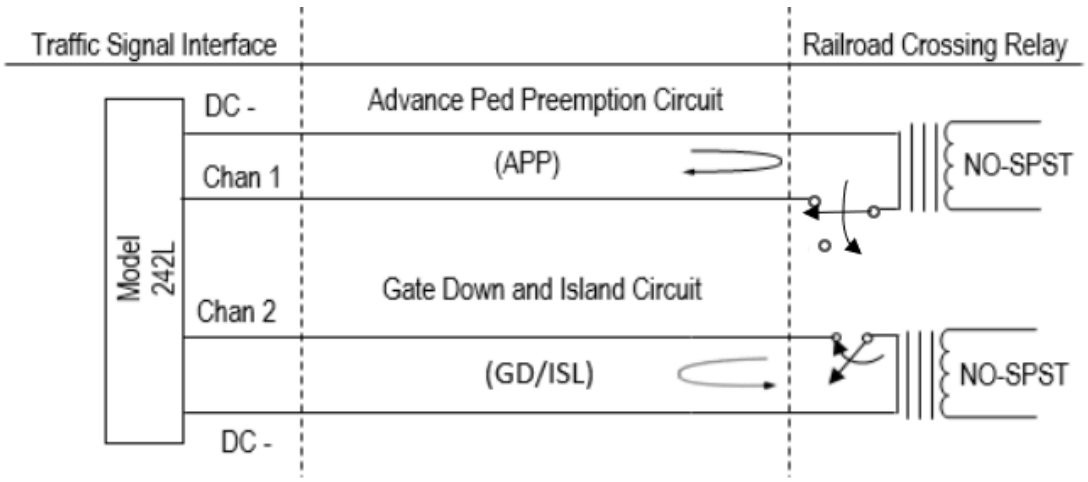

Figure 4: Advance Pedestrian Preemption (APP) Circuit and Gate Down and Island Circuit

7.0 Traffic Signal Health Status (HS) Circuit

The Traffic Signal Health Status (HS) circuit shown in **Figure 5** is a normally energized circuit that provides the health status of the traffic signal to the railroad equipment.

When the circuit is energized, the traffic signal is healthy and operating normal. When the circuit is de-energized, the traffic signal is typically operating in all-red-flash. If the traffic signal is in all-red-flash mode due to railroad preemption, the circuit will remain energized.

The Traffic Signal Health Status circuit consists of a 24 VDC output from the traffic signal control cabinet to the railroad equipment. This circuit uses a redesigned Auxiliary Output File No. 2LX, Model (AUX-RR), for the logic control circuit.

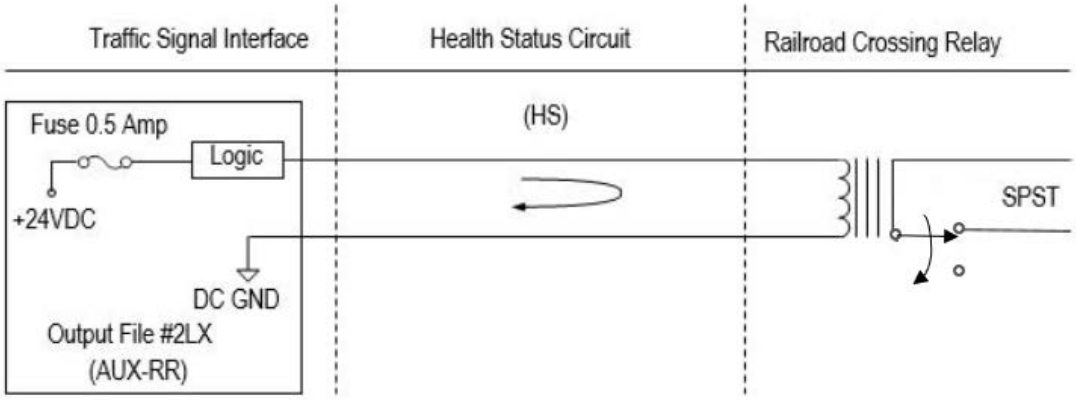

Figure 5: Health Status (HS) Circuit

8.0 Traffic Signal Equipment Requirements

The standard requires circuits for simultaneous preemption, advance preemption, gate down/island, advance pedestrian preemption and traffic signal health status. Implementation requires three slots in the Caltrans Cabinet input file and the following list of equipment:

a)	Three (3) Model 242L DC Isolator Modules
b)	Model 2070 Controller with CTSCP v3
c)	18-Wire, 14 AWG Stranded Conductor, Railroad Interconnect Cable
d)	Output File No. 2 (AUX-RR) and C16 Harness

Table 3: Hardware Requirements

9.0 References

1. "Supervised Interconnection Circuits at Highway-Rail Grade Crossings,"
   By Douglas M. Mansel, Vernon H. Waight and John T. Sharkey,
   ITE Journal, Institute of Transportation Engineers, March 1999.

2. "Preemption of Traffic Signals near Railroad Crossings – An ITE Recommended Practice,"
   Institute of Transportation Engineers, 2006.

3. "Railroad Preemption of Traffic Signals," Letter from CPUC to Caltrans,
   California Public Utilities Commission, July 28, 2016.

10.0 Railroad Preemption Standard Plan Details

ES-P1: Railroad Preemption Wiring (Controller Cabinet to Railroad Details)
ES-P2: Railroad Preemption Wiring (Controller Cabinet Details)
ES-P3: Railroad Preemption Wiring (Retrofit Only)

Table 4: Electrical Design Plans

Dist	COUNTY	LOCATION CODE	POST MILES TOTAL PROJECT	SHEET No.	TOTAL SHEETS

Mohammad Iraki
REGISTERED ELECTRICAL ENGINEER
December 06, 2021
PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER
Mohammad Iraki
No. E21451
Exp. 03-31-22
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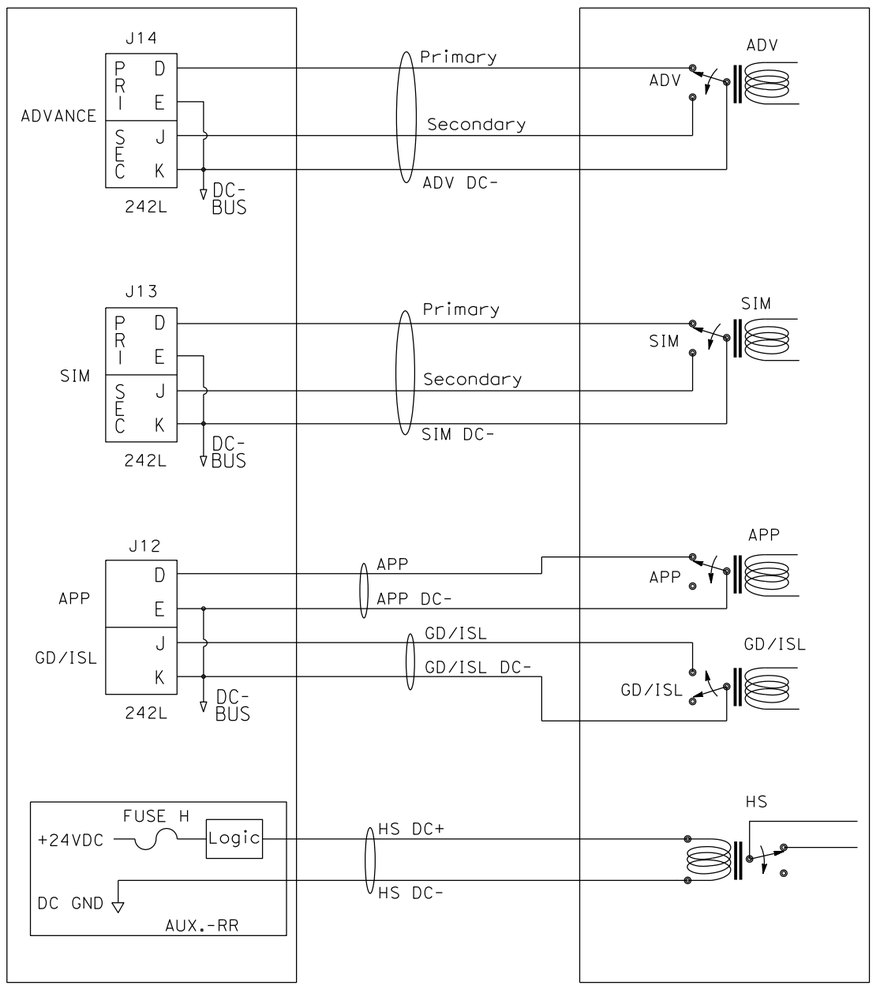
CALTRANS SIDE

RAILROAD SIDE

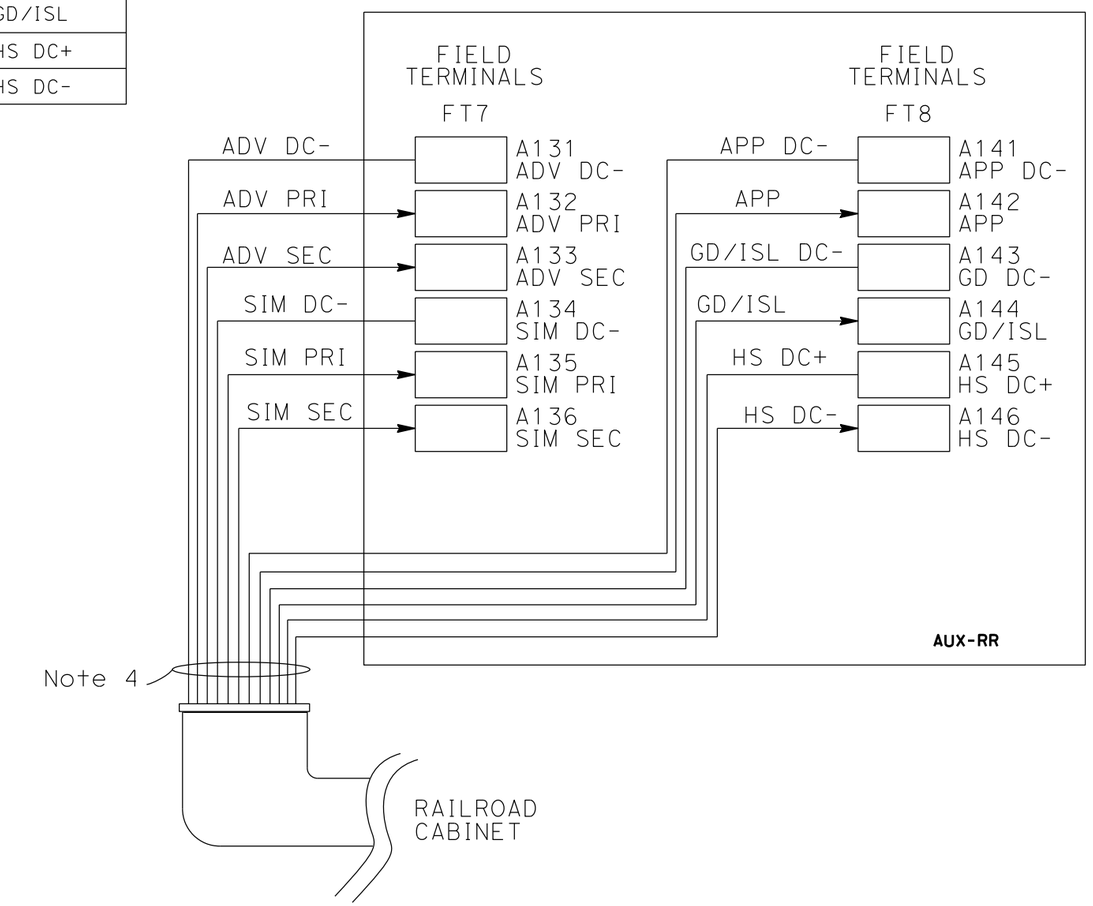


CABLE CONDUCTORS

BASE COLOR	TRACER COLOR	FUNCTION
Blue	-	ADV DC-
Blue	Black	ADV PRI
Blue	White	ADV SEC
Orange	-	SIM DC-
Orange	Black	SIM PRI
Orange	Red	SIM SEC
Green	White	APP DC-
Green	Black	APP
Red	White	GD/ISL DC-
Red	Black	GD/ISL
Red	-	HS DC+
White	Red	HS DC-

See note 3.

CALTRANS CONTROLLER CABINET



ADV INPUT LOGIC

PRI	SEC	STATE
ON	OFF	NORMAL
OFF	ON	PREEMPT
OFF	OFF	FAULT
ON	ON	FAULT

SIM INPUT LOGIC

PRI	SEC	STATE
ON	OFF	NORMAL
OFF	ON	PREEMPT
OFF	OFF	FAULT
ON	ON	FAULT

NOTES: (THIS SHEET ONLY)

1. All dimensions are nominal.
2. ADV = Advance, SIM = Simultanous
   ISL = Island, GD = Gate Down,
   APP = Advance Pedestrian Preemption
   HS = Health Status
   PRI = Primary, SEC = Secondary
3. ICEA/NEMA color code Method 1, Table E-1.
4. 18 Conductors, 14-AWG, stranded conductor Cable.
5. All DC relays shall have flyback diodes.

STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

RAILROAD PREEMPTION WIRING (CONTROLLER CABINET TO RAILROAD DETAILS)

NO SCALE

ES-P1

CALCULATED-DESIGNED BY	REVISED BY	FUNCTIONAL SUPERVISOR	STATE OF CALIFORNIA - DEPARTMENT OF TRANSPORTATION
CHECKED BY	DATE REVISED	Stan Slavin, Jr	
Mohammad Iraki			
Bashir M. Choudry			

LAST REVISION DATE PLOTTED => $DATE
12-06-21 TIME PLOTTED => $TIME

BORDER LAST REVISED 4/11/2008

RELATIVE BORDER SCALE IS IN INCHES 0 1 2 3

USERNAME => Bashir
DGN FILE => PEQUES1

CU 0 000

EA 000000

CONTROLLER CABINET CONNECTIONS

Dist	COUNTY	LOCATION CODE	POST MILES TOTAL PROJECT	SHEET No.	TOTAL SHEETS

REGISTERED ELECTRICAL ENGINEER

December 04, 2019

PLANS APPROVAL DATE

Herasmo Iniguez No. E14813 Exp. 06-30-21 REGISTERED PROFESSIONAL ENGINEER STATE OF CALIFORNIA

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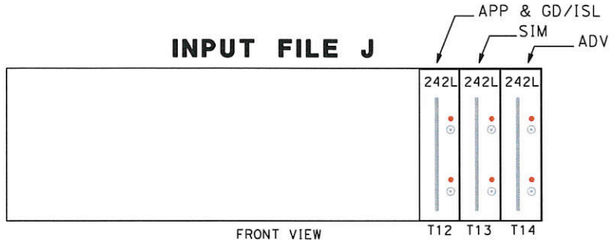
INPUT FILE J



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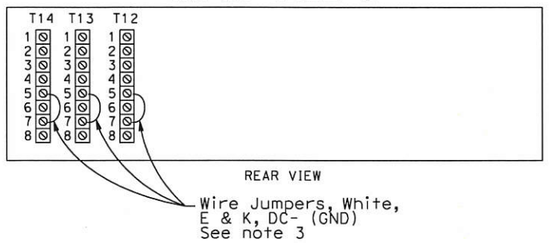
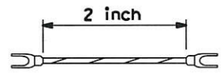


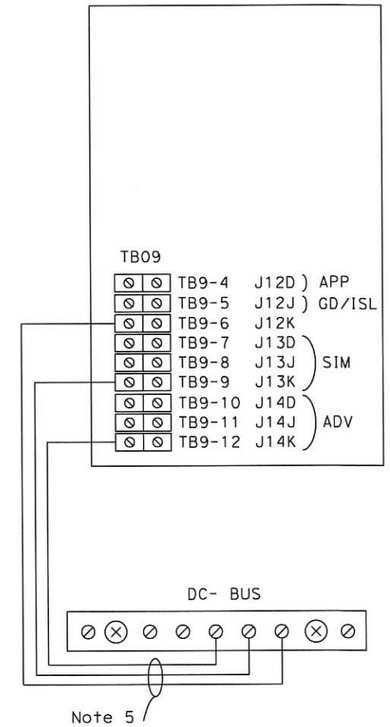


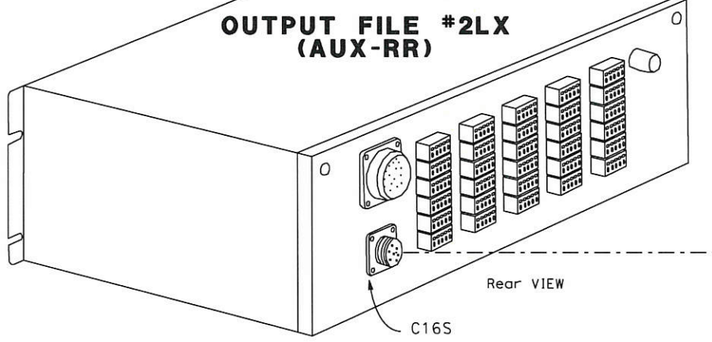
WIRE JUMPER
See Note 3

C16 INPUT PANEL #1

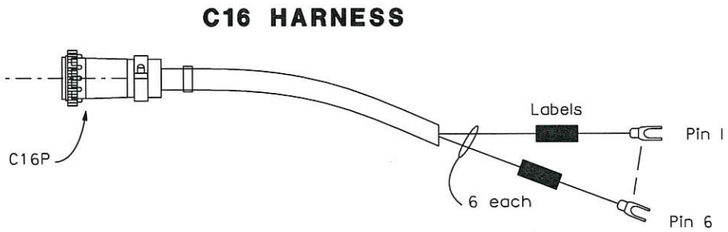
Pin	TB9	Function
1	TB9-4 (J-12D)	APP
2	TB9-5 (J-12J)	GD/ISL
3	TB9-7 (J-13D)	SIM PRI
4	TB9-8 (J-13J)	SIM SEC
5	TB9-10 (J-14D)	ADV PRI
6	TB9-11 (J-14J)	ADV SEC
7	NA	NA
8	NA	NA
9	NA	NA

CABINET INPUT PANEL #1





C16 HARNESS



NOTES: (THIS SHEET ONLY)

1. All dimensions are nominal.
2. ADV = Advance, SIM = Simultanous
   ISL = Island, GD = Gate Down
   APP = Advance Pedestrian Preemption
   HS = Health Status
3. Wire jumpers, 14-AWG, White with Red stripes, stranded with spade connectors shall be placed as shown in the Input File J.
4. Use the C16 Harness as provided to terminate the Railroad interconnections.
5. Install 14-AWG, White with Red stripes, stranded with spade connectors on one side as shown between Input Panel #1 and DC- Bus.

STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

RAILROAD PREEMPTION WIRING (CONTROLLER CABINET DETAILS)

NO SCALE

ES-P2

REVISED BY	DATE REVISED

CALCULATED-DESIGNED BY: Herasmo Iniguez

CHECKED BY: Bashir M. Choudry

FUNCTIONAL SUPERVISOR: Stan Slavin, Jr

STATE OF CALIFORNIA - DEPARTMENT OF TRANSPORTATION

Caltrans

LAST REVISION 12-04-19 | DATE PLOTTED => $DATE | TIME PLOTTED => $TIME

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RELATIVE BORDER SCALE IS IN INCHES 0 1 2 3

USERNAME => Bashir
DGN FILE => $REQUEST

CU 00000

EA 000000

Dist	COUNTY	LOCATION CODE	POST MILES TOTAL PROJECT	SHEET No.	TOTAL SHEETS

REGISTERED ELECTRICAL ENGINEER

December 04, 2019

PLANS APPROVAL DATE

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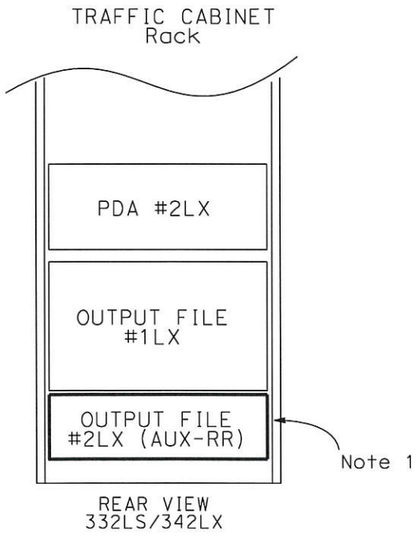
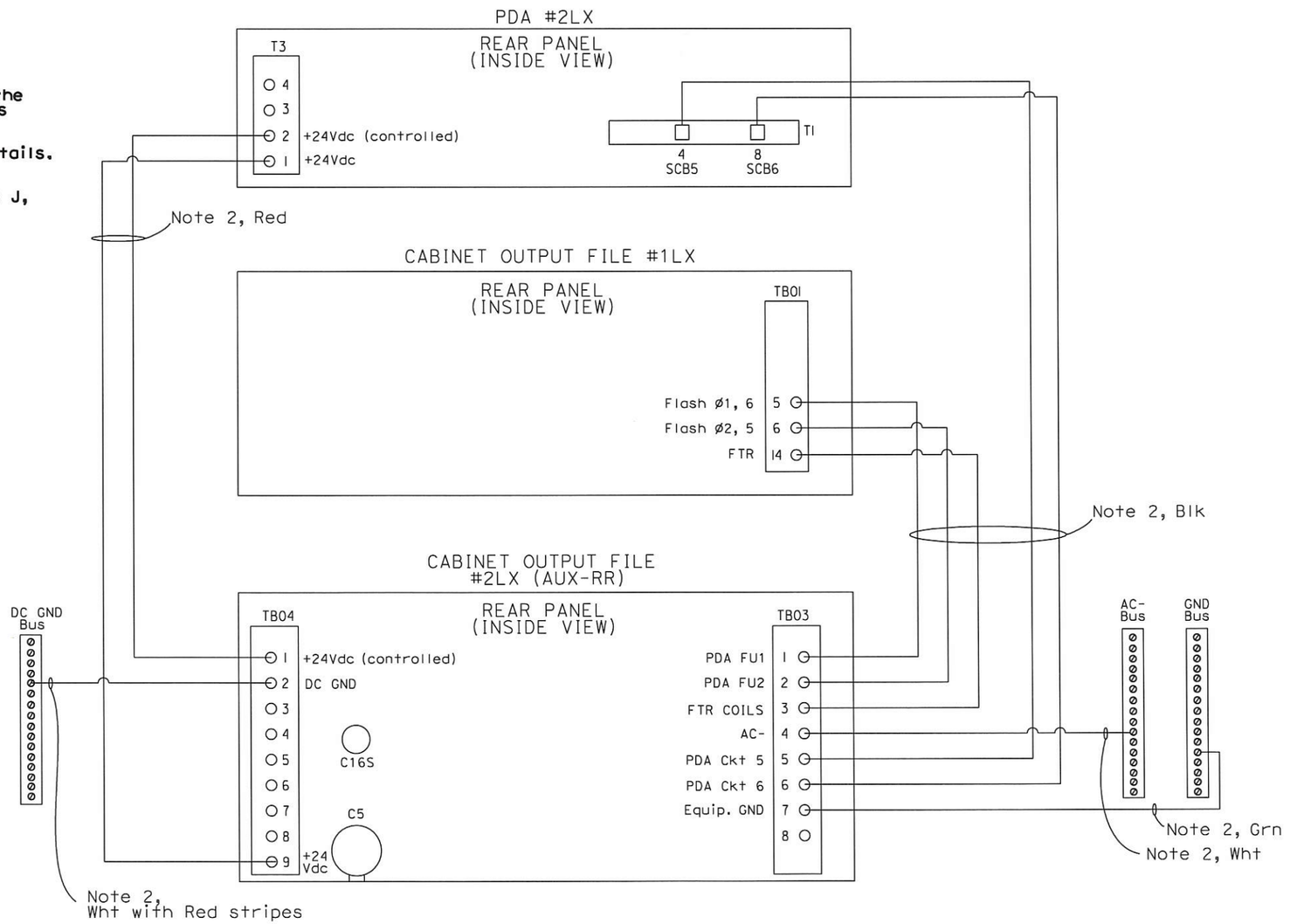
CONTROLLER CABINET RAILROAD RETROFIT

NOTES:

1. Install Output File #2LX (Aux-RR) in the Controller Cabinet.
2. Install 14-AWG conductors as shown.
3. Install Railroad field conductors to Caltrans Controller cabinet's Field Terminals FT7 and FT8, as shown on ES-P1.
4. Connect C16 Harness plug to the C16S socket on the Output File Aux-RR. Connect the other end of this harness with 6 spade connectors to the TB9 of the Input Panel #1. Install 3 conductors from TB09 to the cabinet's DC- Bus. Refer to ES-P2 details.
5. Install 3 Model 242L modules in the Input File J, connect 3 wire jumpers in the back of Input File J, as shown on ES-P2 details.
6. Upgrade TSCP to the Railroad version.





TB=Terminal Block, SCB=Signal Circuit Breaker
PDA=Power Distribution Assembly, Ckt=Circuit,
FU1=Flasher Unit one, FTR=Flash Transfer Relay,
Blk=black, Grn=green, Wht=white.

STATE OF CALIFORNIA
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RAILROAD PREEMPTION WIRING
(RETROFIT ONLY)

NO SCALE

ES-P3

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CHECKED BY: Bashir M. Choudry
FUNCTIONAL SUPERVISOR: Stan Slavin, Jr
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Caltrans

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