

Safety Chain Control System

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Caltrans, District 2

2015

Overview

- Background
 - Chain Control Operations
 - Operational need for change
- Design
 - Initial Design
 - Final Design
- Controlling Electronics
 - Hardware
 - Software
- Deployment
- Functional Testing
- Operational Status
- Lessons Learned
- Questions

Chain Control Operations

- Manually turned chain control signs



Chain Control Operations

- Manually turned chain control signs
- Worker Hazards
 - Traffic



Chain Control Operations

- Manually turned chain control signs
- Worker Hazards
 - Traffic
 - Limited visibility



Chain Control Operations

- Manually turned chain control signs
- Worker Hazards
 - Traffic
 - Limited visibility
 - Severe weather



Chain Control Operations

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 - Limited visibility
 - Severe weather
 - Icy Roadways



Chain Control Operations

- Manually turned chain control signs
- Worker Hazards
 - Traffic
 - Limited visibility
 - Severe weather
 - Icy Roadways
 - Workers on foot



Operational Need for Change

Existing Chain Control System (Anderson Grade Pass)



Anderson Grade Summit, 3067'

Western State Forum

Chain Control Location 1,
Yreka, CA

Operational Need for Change

Existing Chain Control System (Anderson Grade Pass)



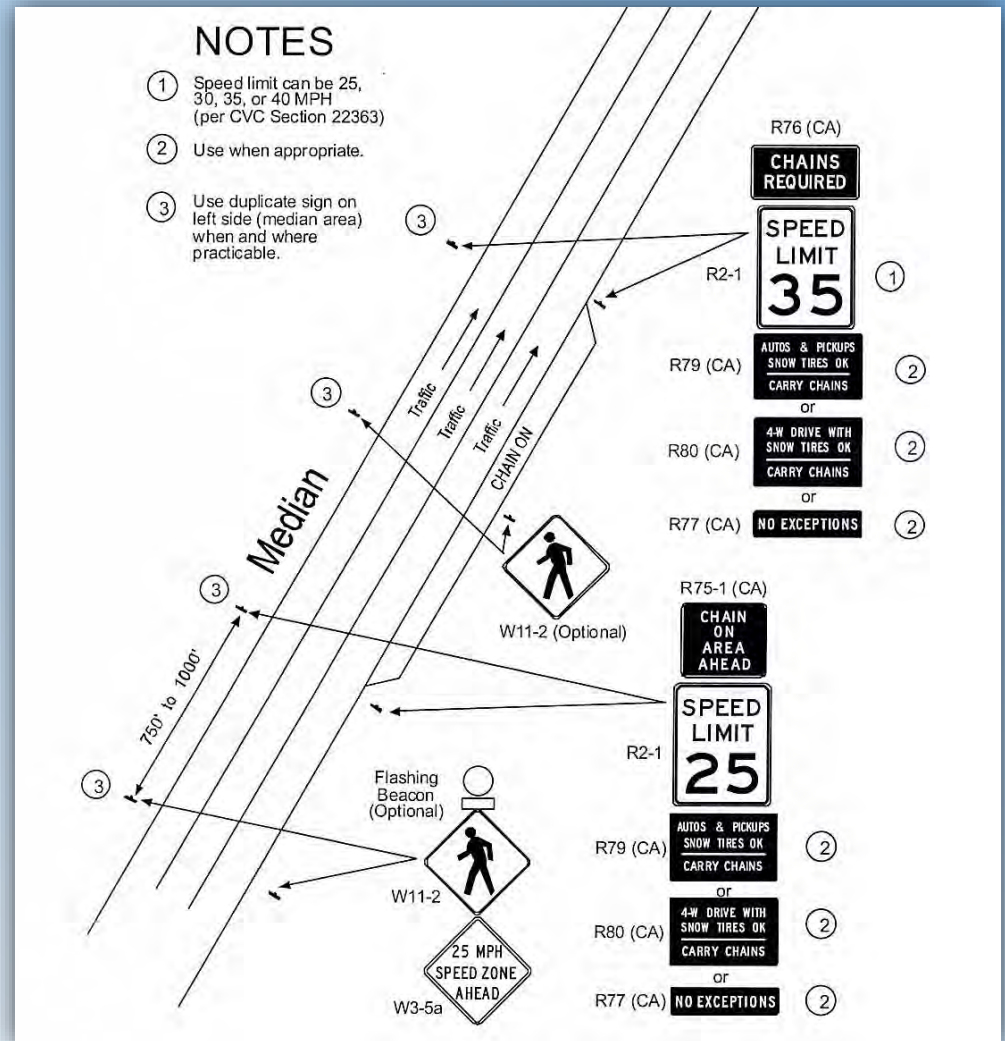
Chain Control Location 2, Hornbrook, CA

Anderson Grade Summit, 3067'

Operational Need for Change

Existing Installation for Multilane Highways

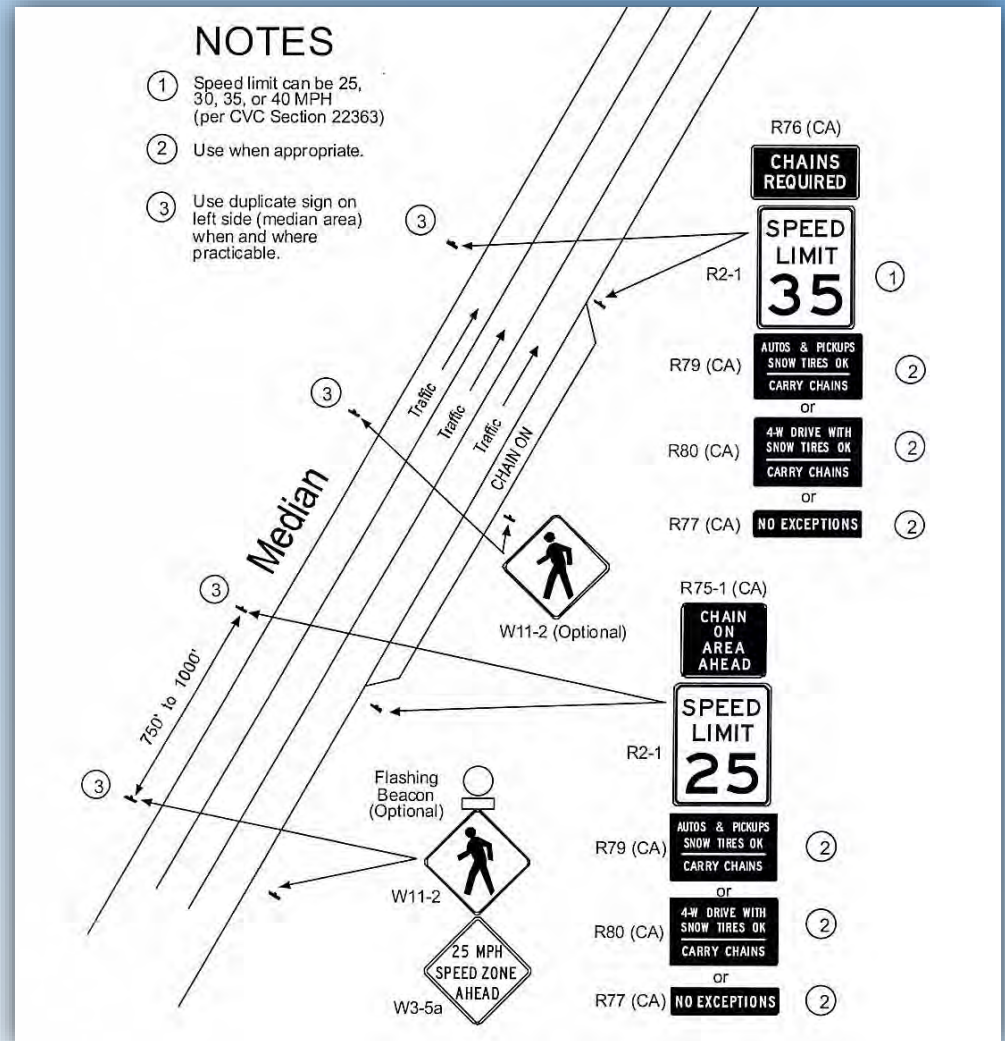
- Each sign must be manually turned



Operational Need for Change

Existing Installation for Multilane Highways

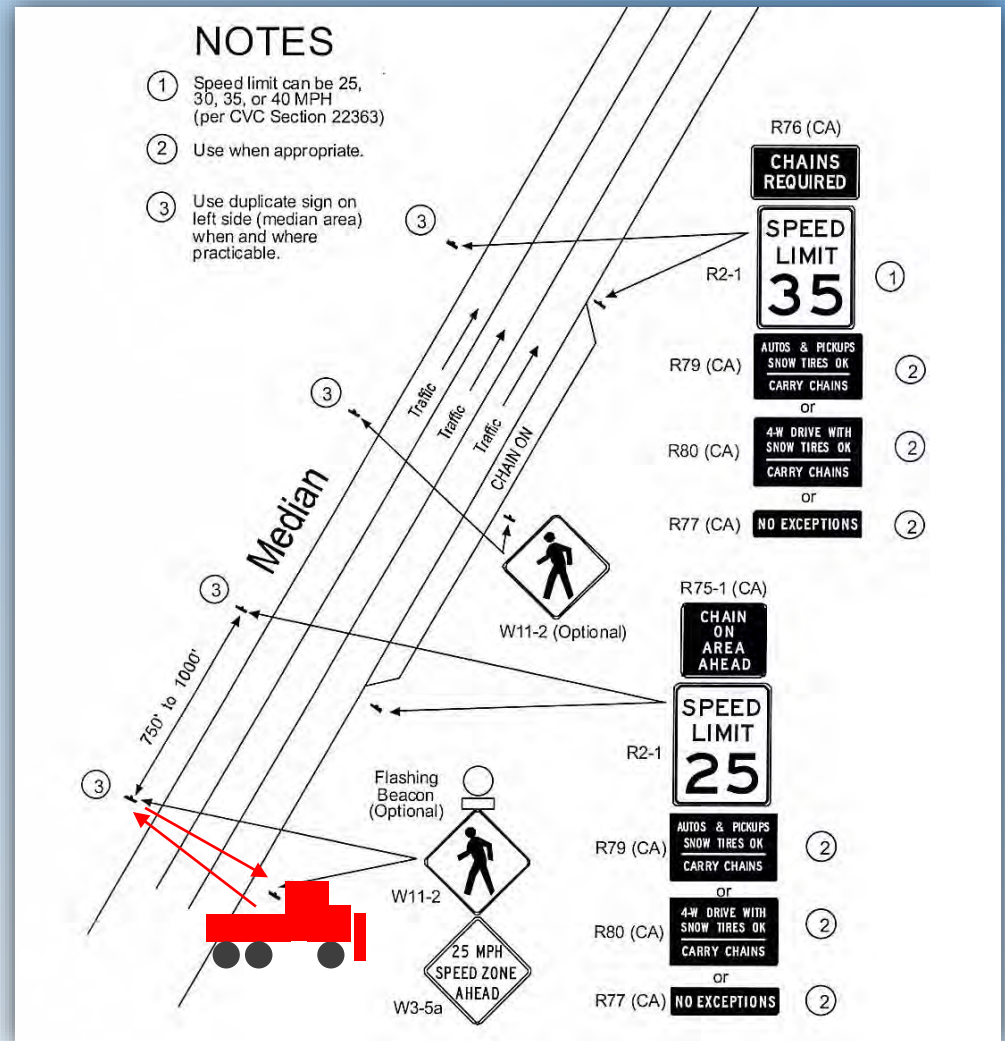
- Each sign must be manually turned
- Requires workers to be on foot in poor conditions



Operational Need for Change

Existing Installation for Multilane Highways

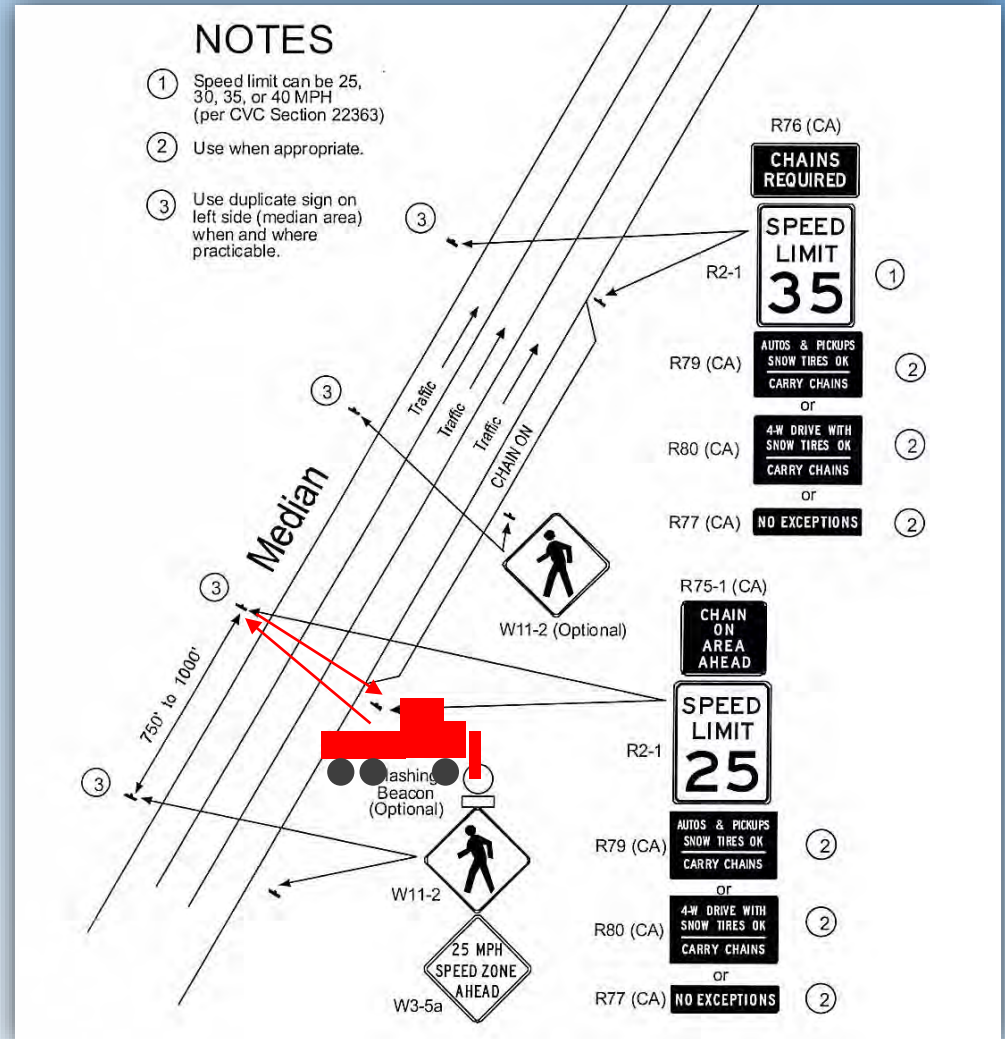
- Turn 1st set of signs
 - Traverse highway twice



Operational Need for Change

Existing Installation for Multilane Highways

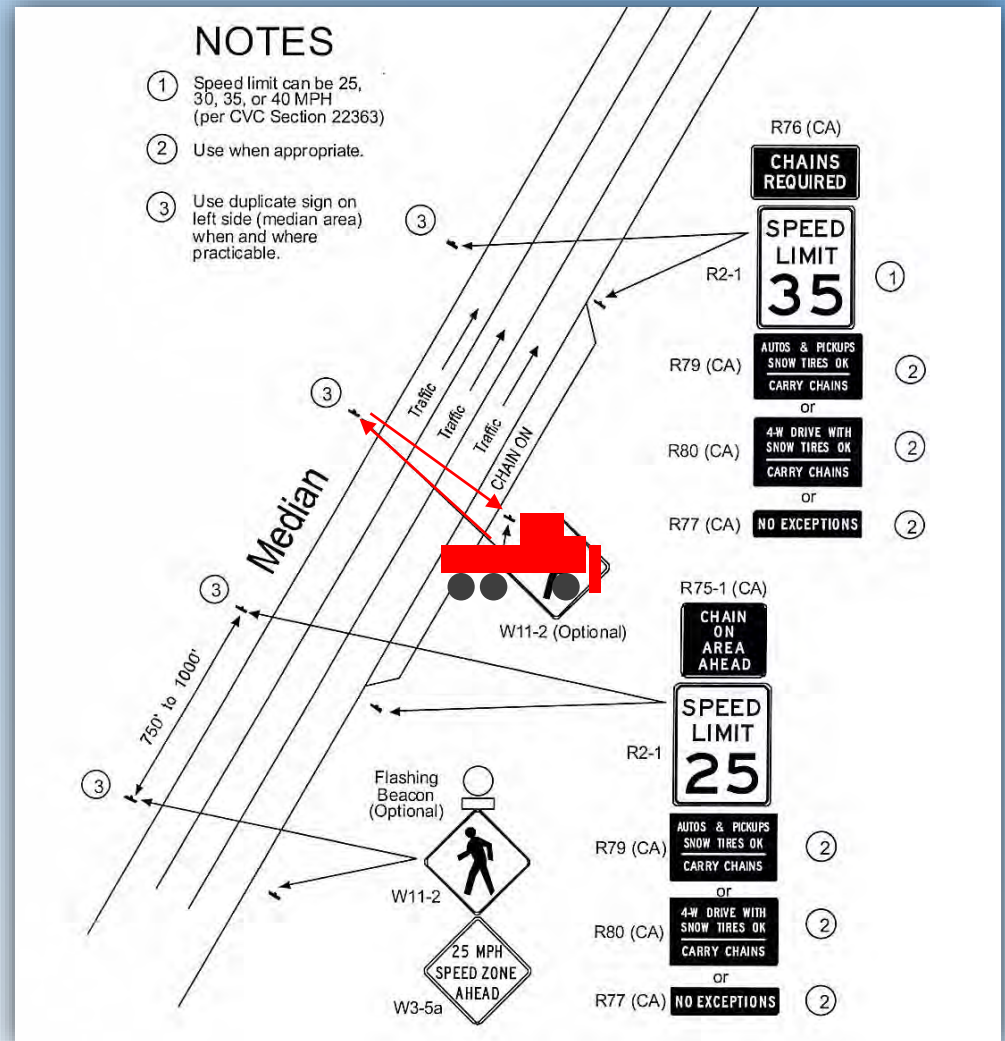
- Turn 1st set of signs
 - Traverse highway twice
- Turn 2nd set of signs
 - Traverse highway twice



Operational Need for Change

Existing Installation for Multilane Highways

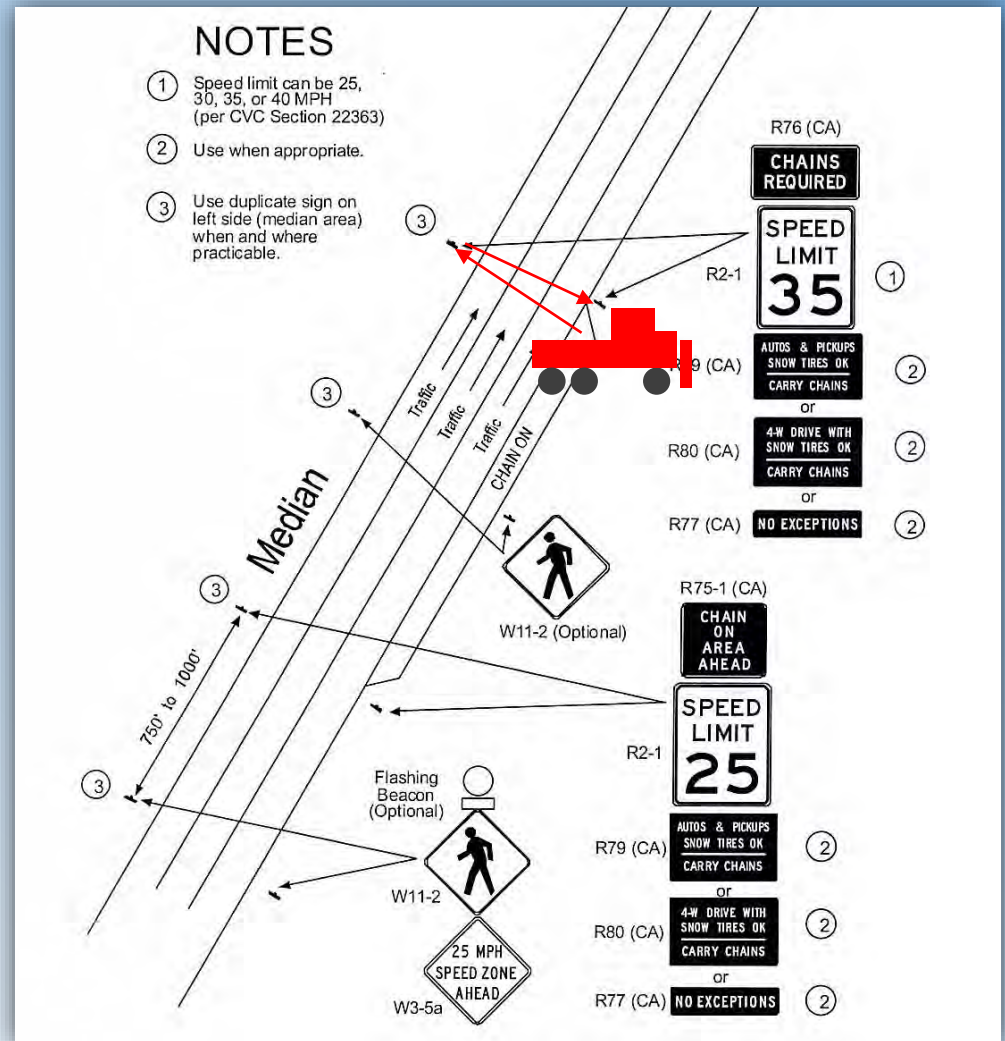
- Turn 1st set of signs
 - Traverse highway twice
- Turn 2nd set of signs
 - Traverse highway twice
- Turn 3rd set of signs
 - Traverse highway twice



Operational Need for Change

Existing Installation for Multilane Highways

- Turn 1st set of signs
 - Traverse highway twice
- Turn 2nd set of signs
 - Traverse highway twice
- Turn 3rd set of signs
 - Traverse highway twice
- Turn 4th set of signs
 - Traverse highway twice

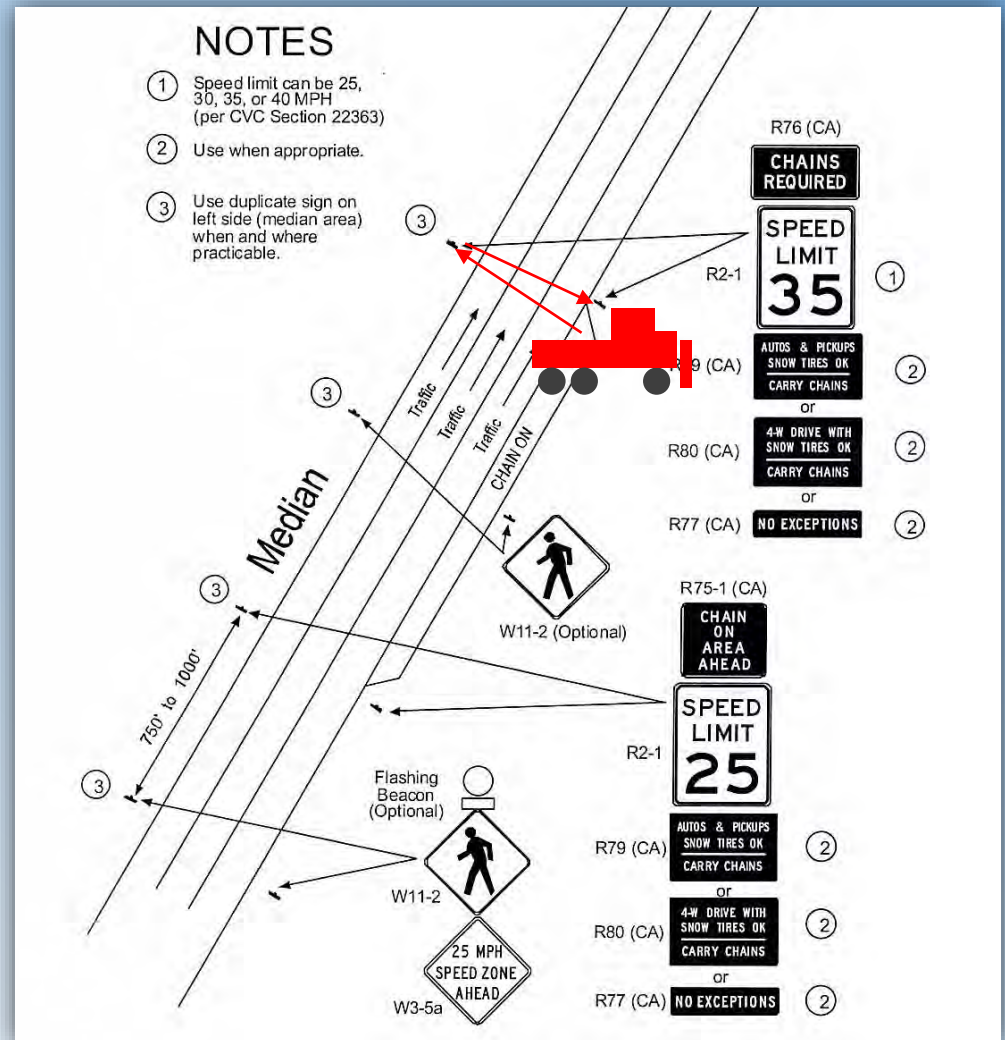


Operational Need for Change

Existing Installation for Multilane Highways

- Turn 1st set of signs
 - Traverse highway twice
- Turn 2nd set of signs
 - Traverse highway twice
- Turn 3rd set of signs
 - Traverse highway twice
- Turn 4th set of signs
 - Traverse highway twice

Worker must traverse the highway 8 times!



Initial Design

- Develop two independent systems that allow maintenance crews **remotely** turn on chain control signs via telephone.
 - One located in Yreka, CA
 - One located in Hornbrook, CA
- Each system would consist of signage and controlling electronics.
- Each system would have a single controlling cabinet.

Initial Design

Small Changeable Message Sign vs Static Signs

- Small Changeable Message Sign
 - 3 lines, 8 characters per line



Initial Design

Small Changeable Message Sign vs Static Signs

- Small Changeable Message Sign
 - 3 lines, 8 characters per line
 - R1 Modified would require **3** panels

R1 Modified

**“CHAINS REQUIRED ON SINGLE AXLE DRIVE
VEHICLE WITH TRAILER”**

Initial Design

Small Changeable Message Sign vs Static Signs

- Small Changeable Message Sign
 - 3 lines, 8 characters per line
 - R1 Modified would require **3** panels



R1 Modified Example

Initial Design

Small Changeable Message Sign vs Static Signs

- Small Changeable Message Sign
 - 3 lines, 8 characters per line
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R1 Modified Example

Initial Design

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R1 Modified Example

Initial Design

Small Changeable Message Sign vs Static Signs

- Small Changeable Message Sign
 - 3 lines, 8 characters per line
 - R1 Modified would require **3** panels
 - R1 would require **4** panels

R1

**“CHAINS REQUIRED AUTOS & PICKUPS SNOW
TIRES OK – CARRY CHAINS”**

Initial Design

Small Changeable Message Sign vs Static Signs

- Small Changeable Message Sign
 - 3 lines, 8 characters per line
 - R1 Modified would require **3** panels
 - R1



R1 Example

Initial Design

Small Changeable Message Sign vs Static Signs

- Small Changeable Message Sign
 - 3 lines, 8 characters per line
 - R1 Modified would require **3** panels
 - R1



R1 Example

Initial Design

Small Changeable Message Sign vs Static Signs

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 - R1



R1 Example

Initial Design

Small Changeable Message Sign vs Static Signs

- Small Changeable Message Sign
 - 3 lines, 8 characters per line
 - R1 Modified would require **3** panels
 - R1



R1 Example

Initial Design

Small Changeable Message Sign vs Static Signs

- Small Changeable Message Sign
 - 3 lines, 8 characters per line
 - R1 Modified would require **3** panels
 - R1 would require **4** panels
 - R2 would require **4** panels

R2

**“CHAINS REQUIRED 4-W DRIVE WITH SNOW
TIRES OK – CARRY CHAINS”**

Initial Design

Small Changeable Message Sign vs Static Signs

- Small Changeable Message Sign
 - 3 lines, 8 characters per line
 - R1 Modified would require **3** panels
 - R1
 - R2



R2 Example

Initial Design

Small Changeable Message Sign vs Static Signs

- Small Changeable Message Sign
 - 3 lines, 8 characters per line
 - R1 Modified would require **3** panels
 - R1
 - R2



R2 Example

Initial Design

Small Changeable Message Sign vs Static Signs

- Small Changeable Message Sign
 - 3 lines, 8 characters per line
 - R1 Modified would require **3** panels
 - R1
 - R2



R2 Example

Initial Design

Small Changeable Message Sign vs Static Signs

- Small Changeable Message Sign
 - 3 lines, 8 characters per line
 - R1 Modified would require **3** panels
 - R1
 - R2



R2 Example

Initial Design

Small Changeable Message Sign vs Static Signs

- Small Changeable Message Sign
 - 3 lines, 8 characters per line
 - R1 Modified would require **3** panels
 - R1 would require **4** panels
 - R2 would require **4** panels

Maximum of two panels are allowed on a CMS.

“Each message shall consist of no more than two phases. A phase shall consist of no more than three lines of text. Each phase shall be understood by it self regardless of the sequence in which it is read...”

California Manual on Uniform Traffic Control Devices (CA MUTCD) Section 2L.05.04

Initial Design

Small Changeable Message Sign vs Static Signs

- Static Signs
 - Existing Standard Signs



Initial Design

Small Changeable Message Sign vs Static Signs

- Static Signs
 - Existing Standard Signs



Initial Design

Small Changeable Message Sign vs Static Signs

- Static Signs
 - Existing Standard Signs



Initial Design

Small Changeable Message Sign vs Static Signs

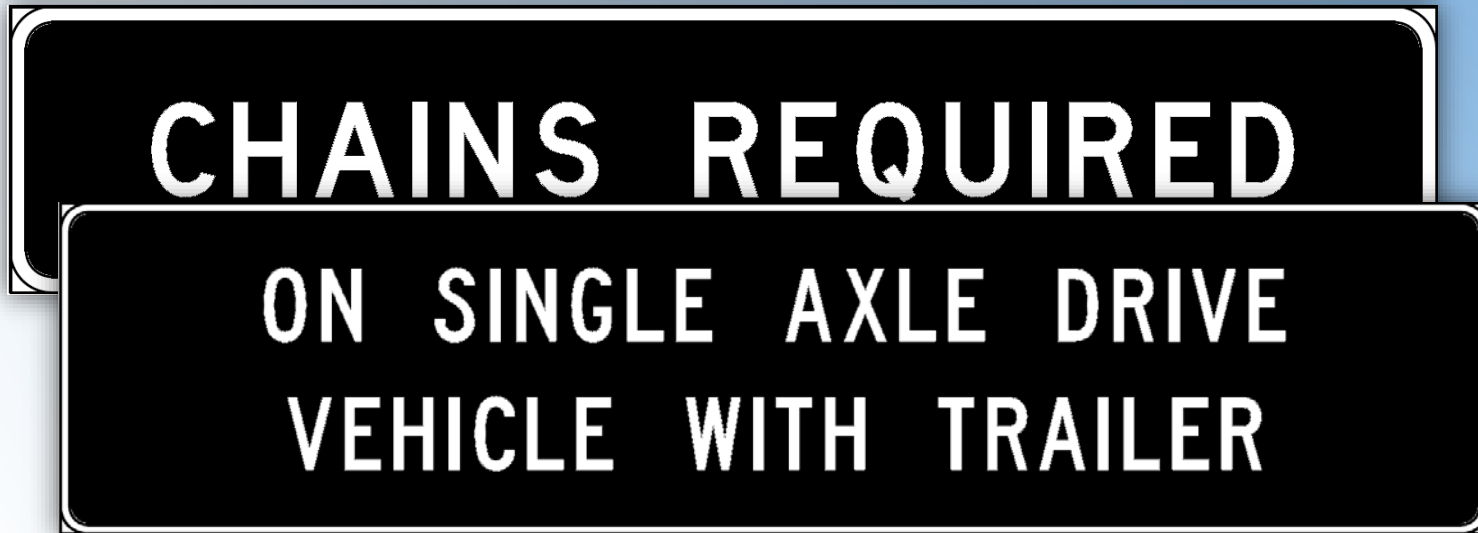
- Use Static Signs based on Standard Signs



Initial Design

Small Changeable Message Sign vs Static Signs

- Use Static Signs based on Standard Signs



Initial Design

Small Changeable Message Sign vs Static Signs

- Use Static Signs based on Standard Signs

CHAINS REQUIRED

ON SINGLE AXLE DRIVE

**AUTOS & PICKUPS SNOW
TIRES OK - CARRY CHAINS**

Initial Design

Small Changeable Message Sign vs Static Signs

- Use Static Signs based on Standard Signs

CHAINS REQUIRED

ON SINGLE AXLE DRIVE

AUTOS & PICKUPS SNOW

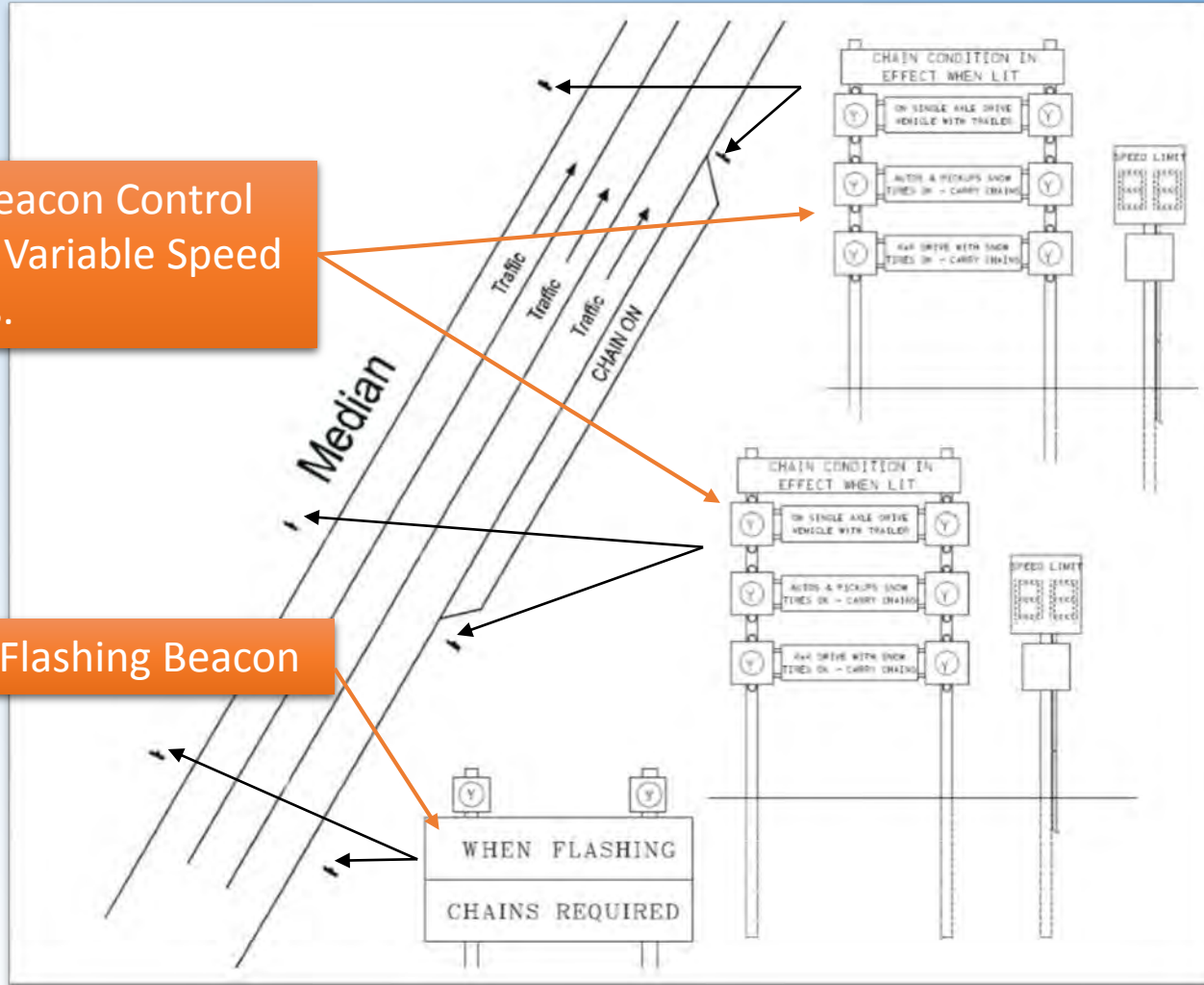
**4x4 DRIVE WITH SNOW
TIRES OK – CARRY CHAINS**

Initial Design

Sign Layout

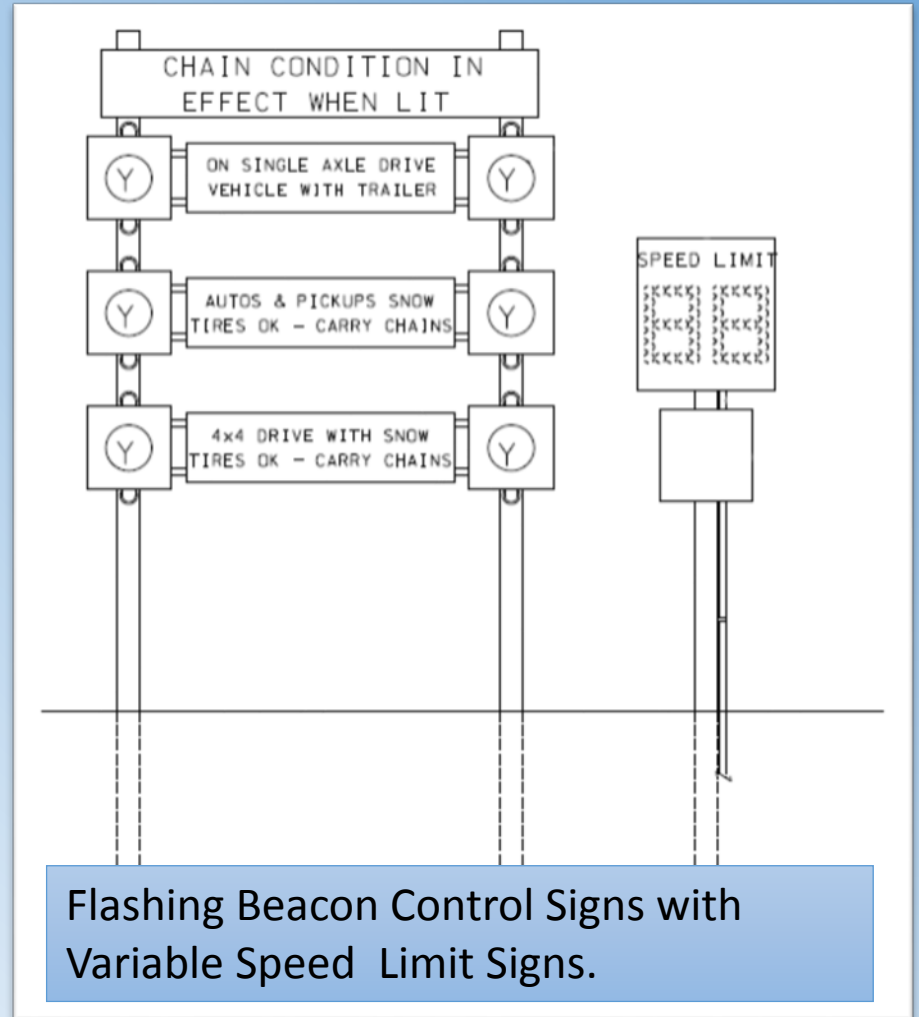
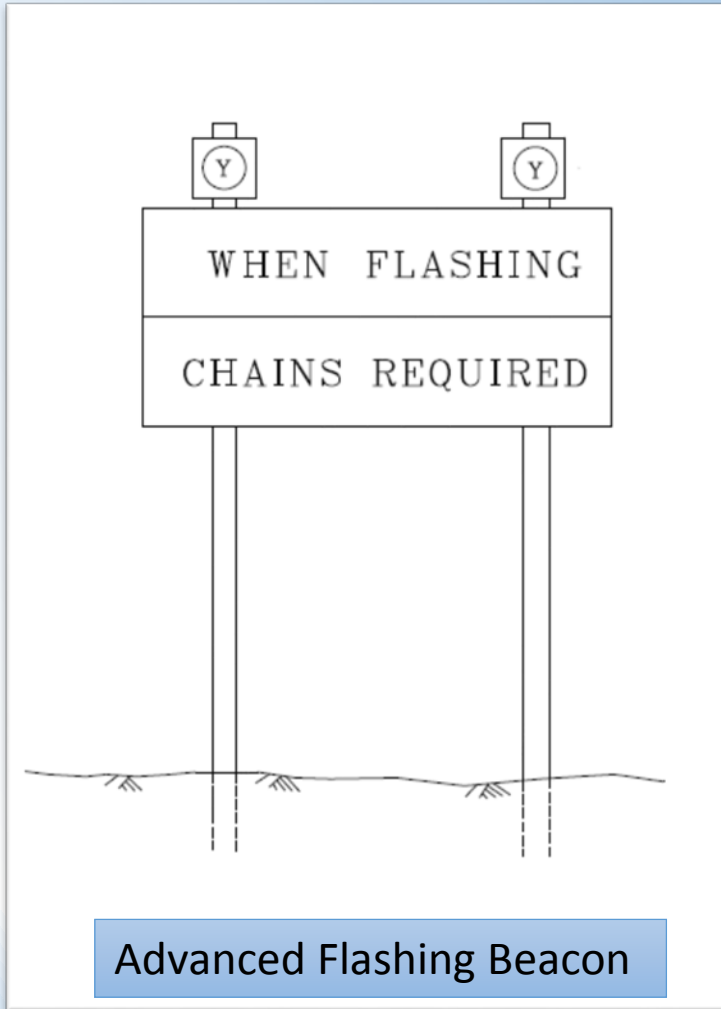
Flashing Beacon Control Signs with Variable Speed Limit Signs.

Advanced Flashing Beacon



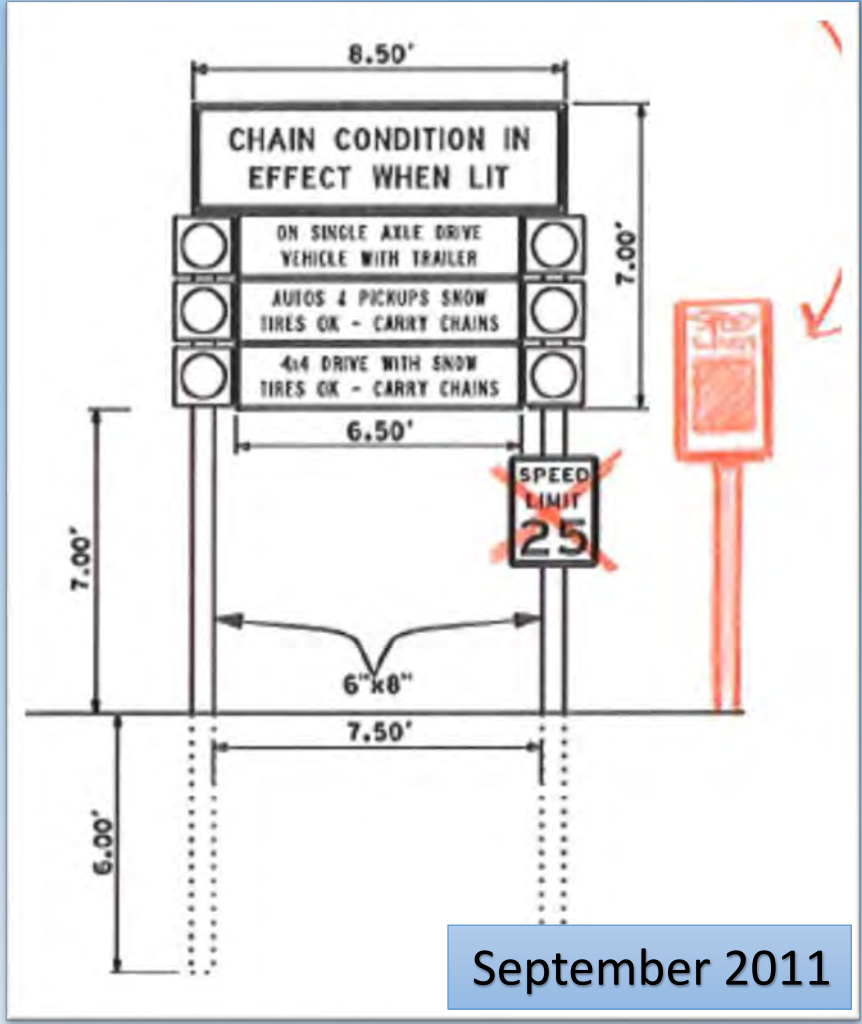
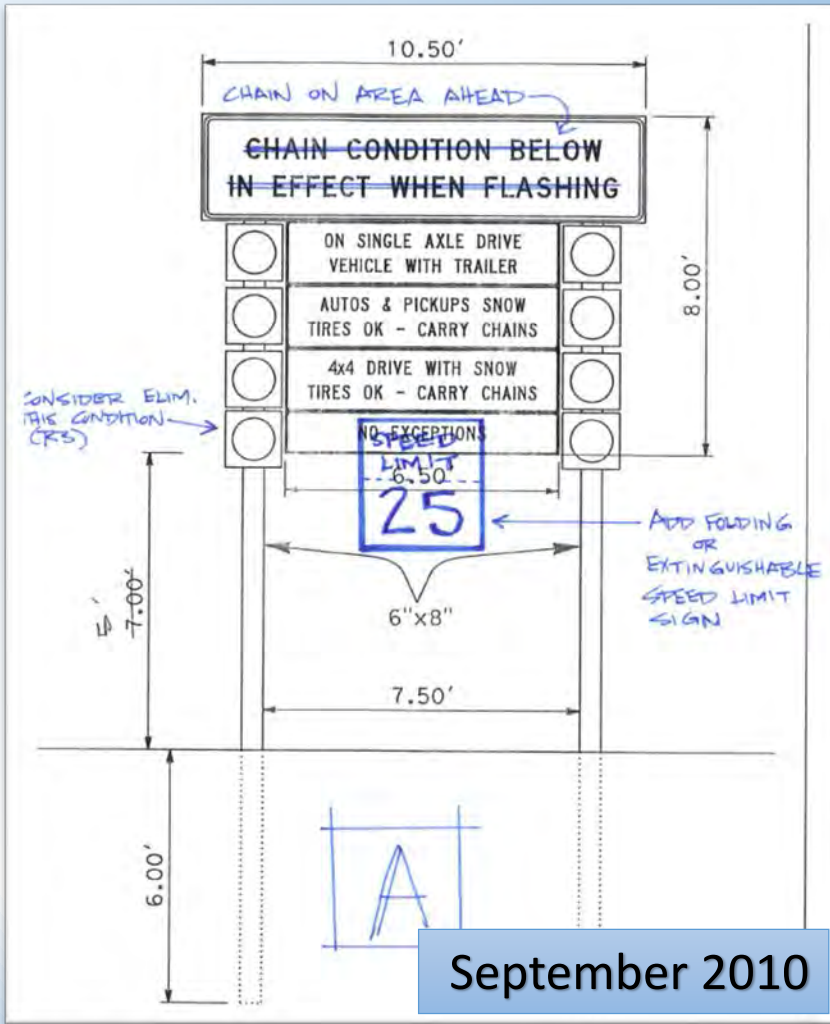
Initial Design

Sign Structure



Initial Design

Sign Structure (Initial Variants)



Initial Design

Speed Limit Sign

- Display enforceable speed limit sign
 - Foldable Sign (Fixed Sign)



Initial Design

Speed Limit Sign

- Display enforceable speed limit sign
 - Foldable Sign (Fixed Sign)
 - Extinguishable Message Sign (EMS)



Initial Design

Speed Limit Sign

- Display enforceable speed limit sign
 - Foldable Sign (Fixed Sign)
 - Extinguishable Message Sign (EMS)
 - Variable Speed Limit Sign (VSL)



Initial Design

Controller Cabinet

- All controlling electronics will be located in a District 2 ITS Flashing Beacon Controller cabinet
 - Custom 332/334 Controller Cabinet

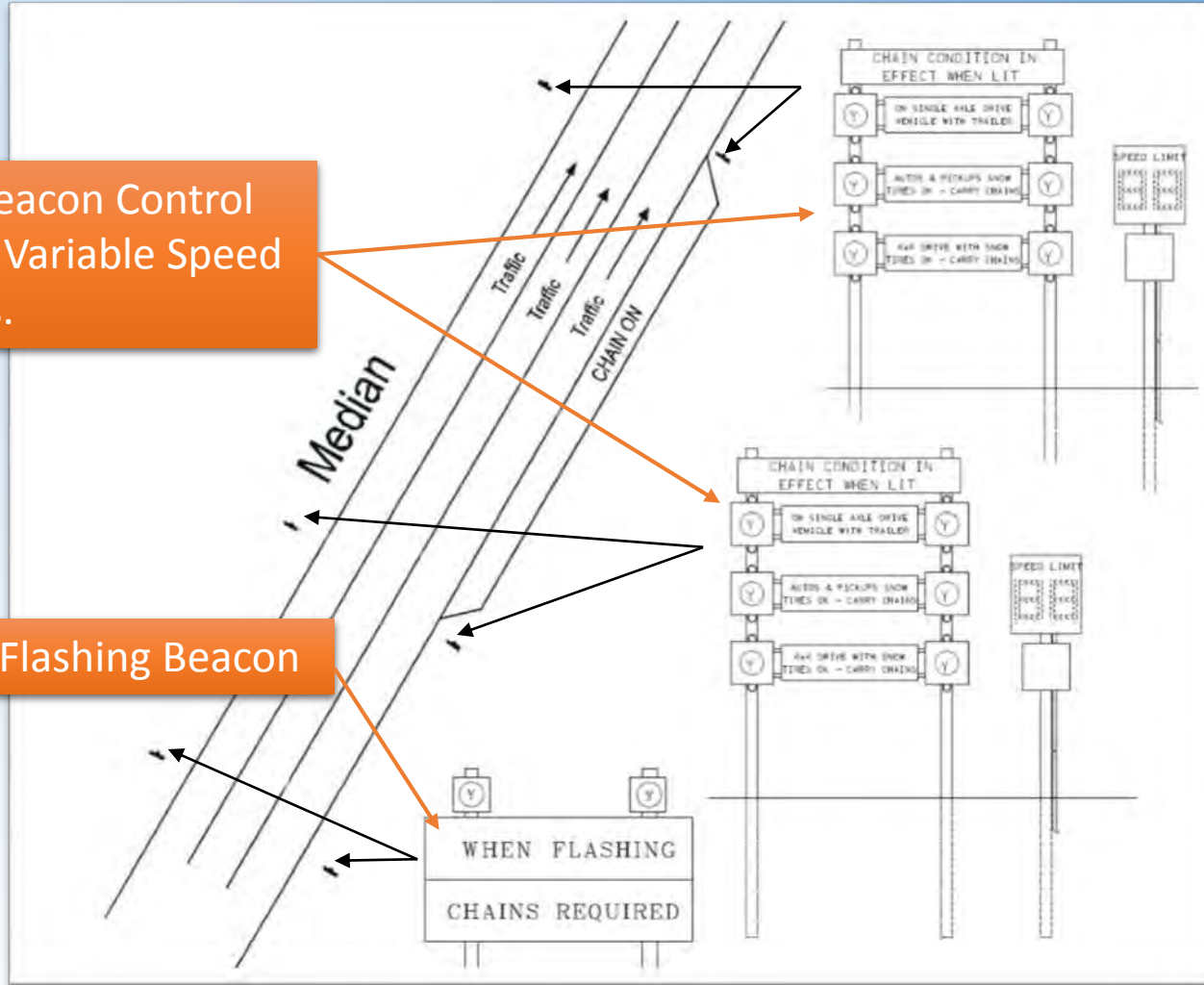


Final Design

Sign Layout

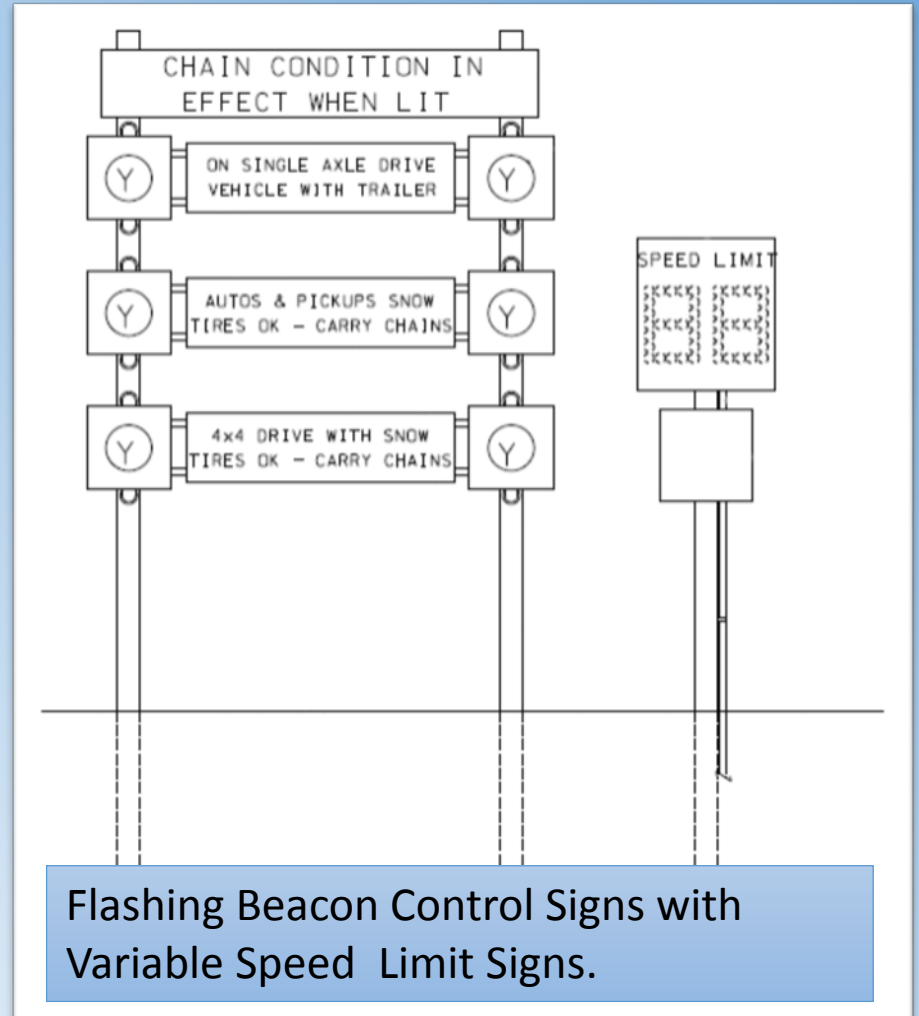
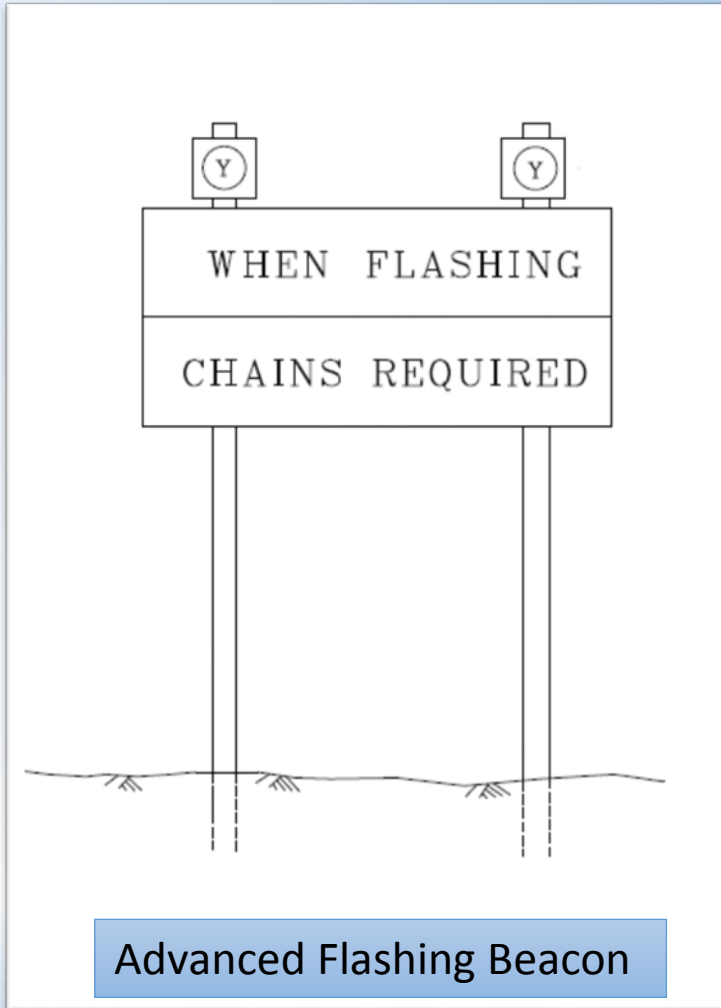
Flashing Beacon Control Signs with Variable Speed Limit Signs.

Advanced Flashing Beacon



Final Design

Sign Structure



Final Design

Speed Limit Sign

- Information Display
Company SpeedCheck
VSL-18
 - Meets MUTCD
 - 18" LED display
 - Enforceable



Final Design

Controller Cabinet

- District 2 ITS Flashing Beacon Controller cabinet



Controlling Electronics

Hardware

- Schneider Electric Zelio Logic Smart Relay (SR2 B121BD)
 - Number or control scheme lines
 - 120 Ladder Logic Lines (LD)
 - ≤ 200 with Function Block Diagram (FBD)
 - Inputs
 - 4 Discrete (24 V DC)
 - 4 Discrete or Analog (0-24 V DC)
 - Outputs
 - 4 normally open relay outputs
 - 5-30 V DC
 - 24-250 V AC
 - Power Requirements
 - 24 V DC at 100mA



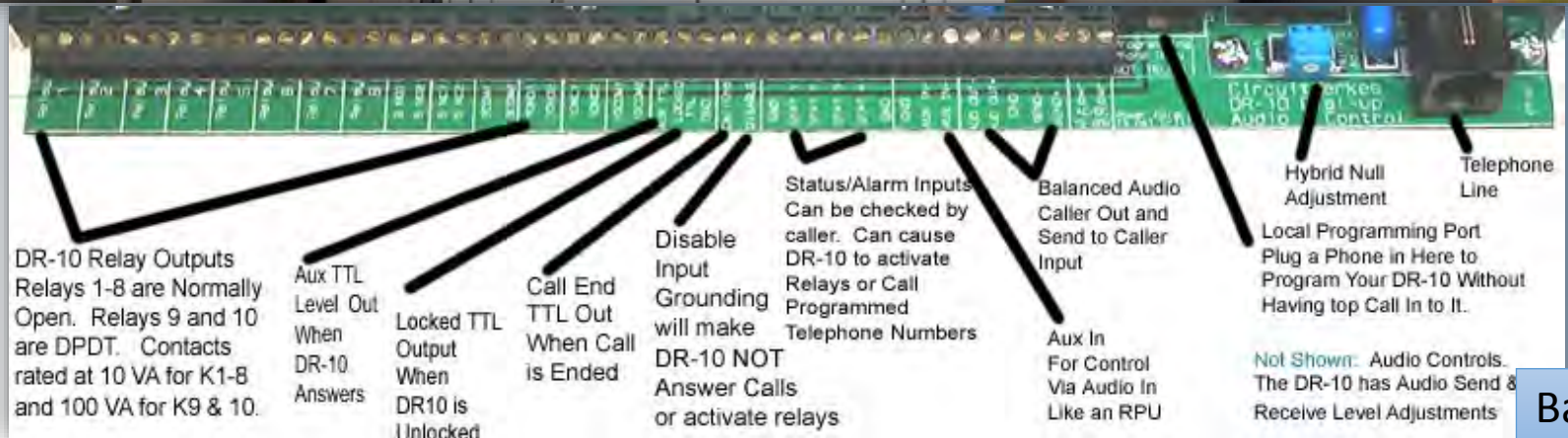
Controlling Electronics

Hardware

- CircuitWerkes DR-10 Dial-up Remote Control
 - DTMF microprocessor based remote control
 - **Allows for system control by telephone**
 - Easily programmable
 - Relays
 - 8 Normally Open contacts rated at 10VA



Front



Back

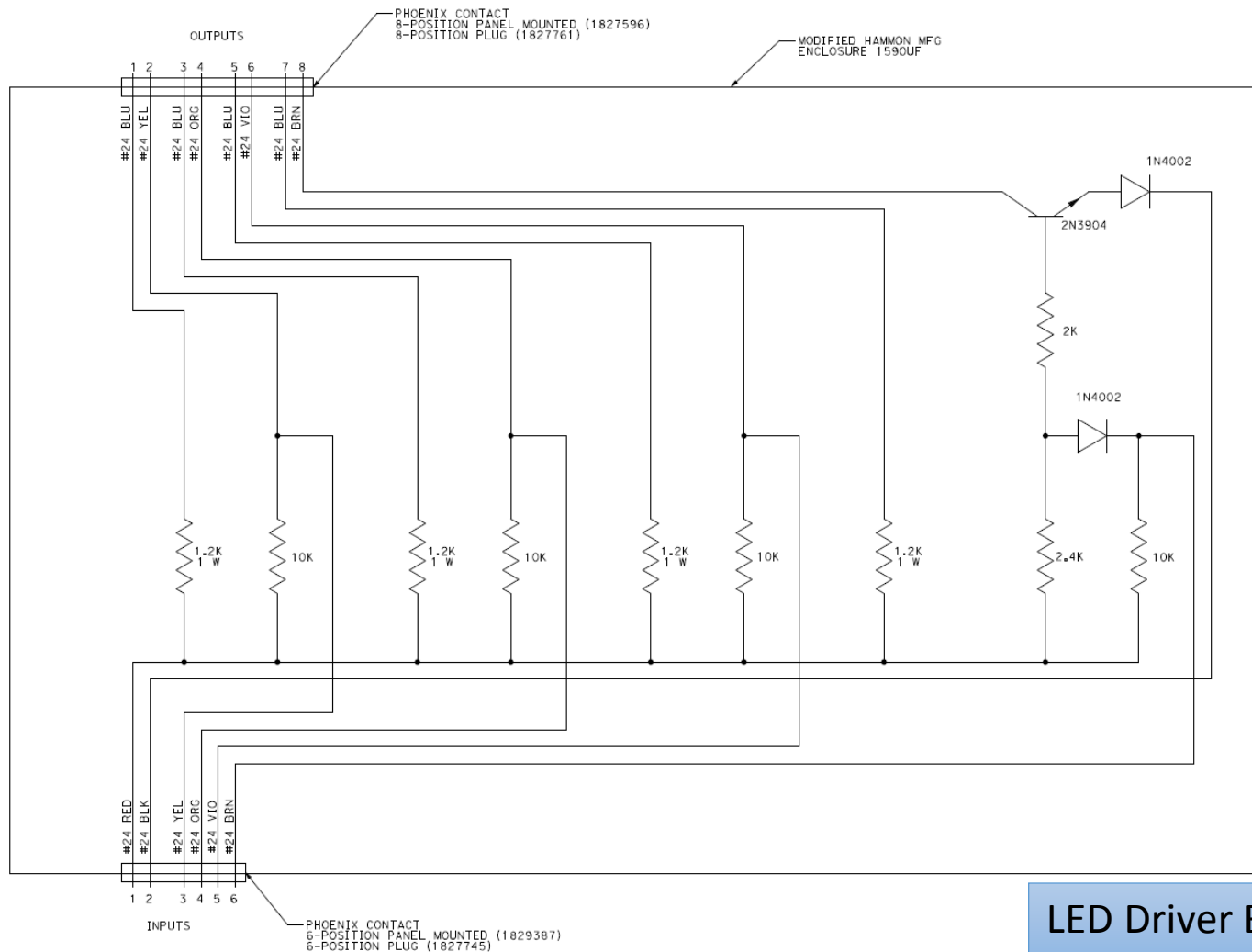
Controlling Electronics

Hardware

- Police Panel Push Button Controls
 - Custom Placard
 - Backlit LED momentary push buttons



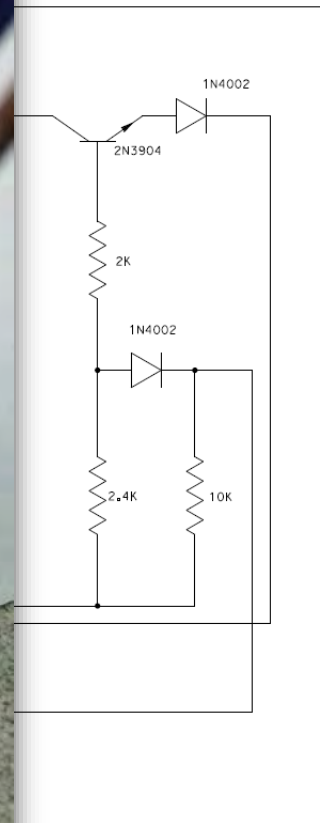
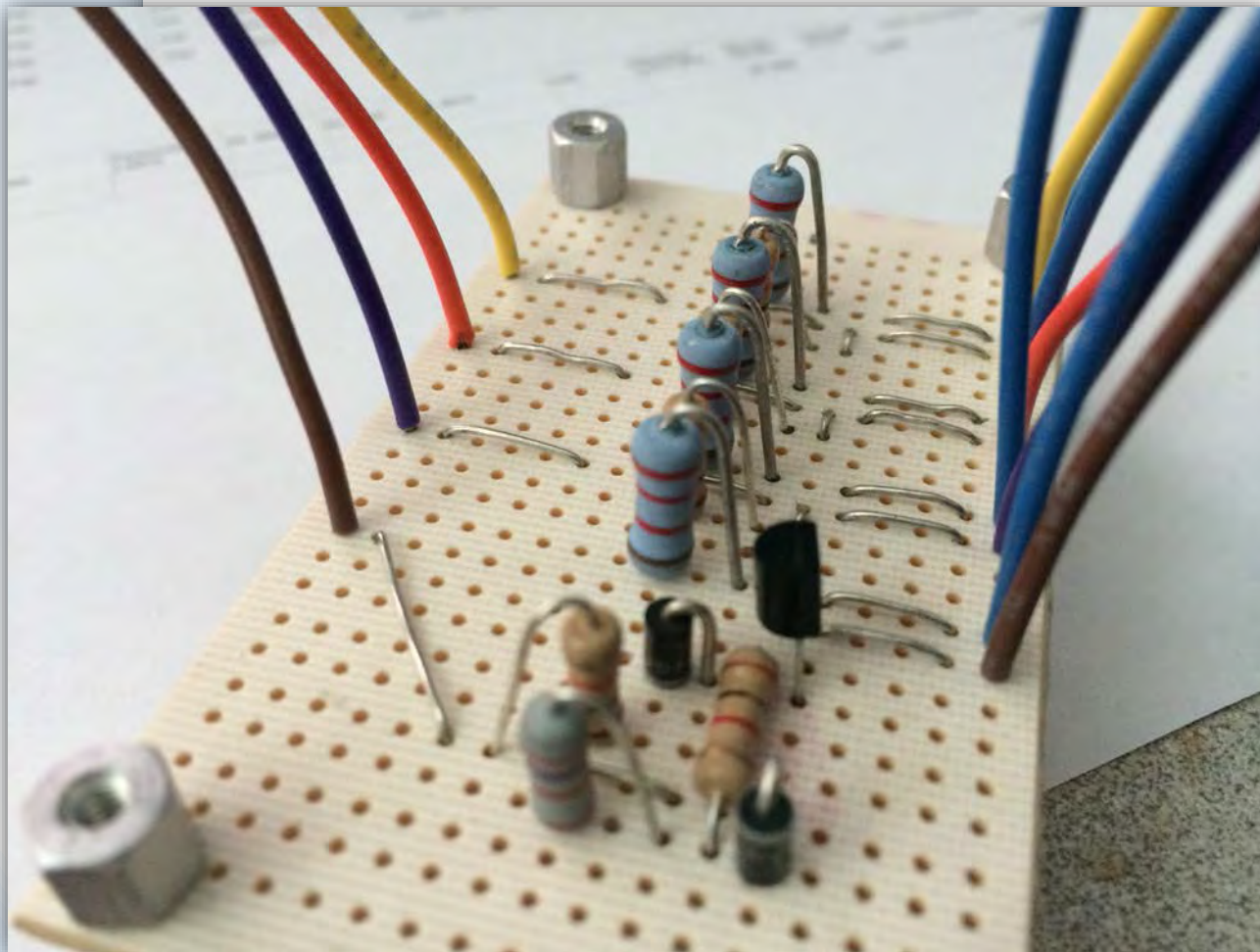
Controlling Electronics Hardware



LED Driver Board

Controlling Electronics

Custom Electronics



INPUTS

PHOENIX CONTACT
6-POSITION PANEL MOUNTED (1829387)
6-POSITION PLUG (1827745)

LED Driver Board

Controlling Electronics

Custom Electronics Box



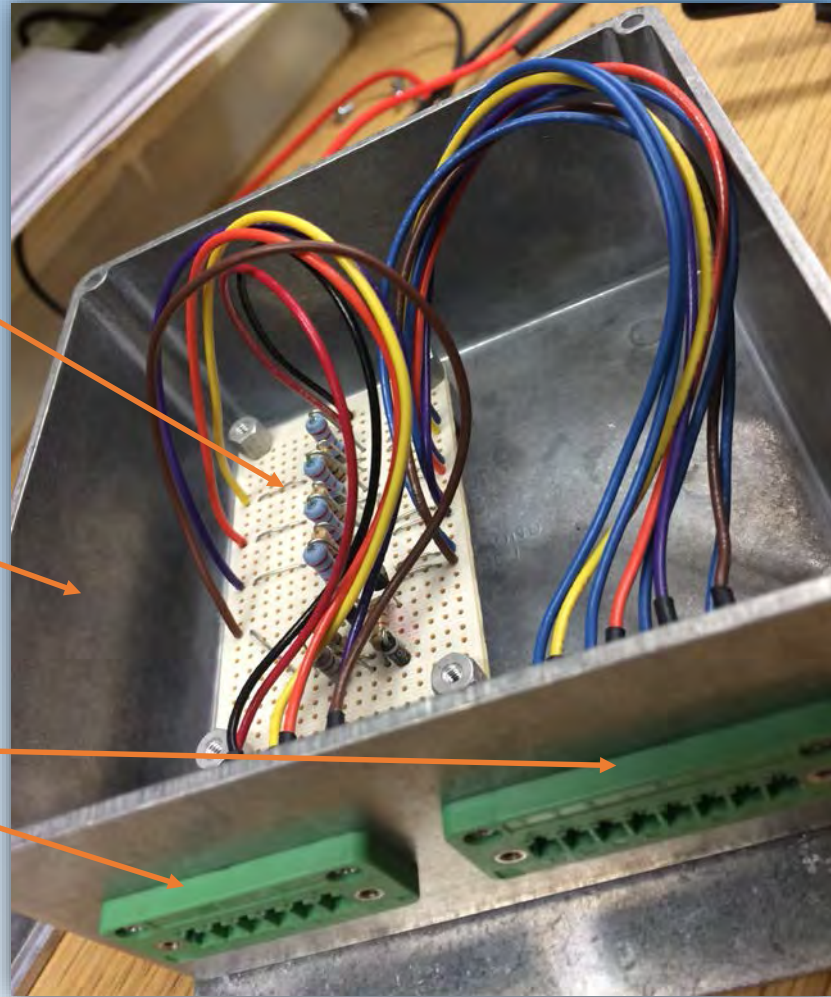
Controlling Electronics

Custom Electronics Box

LED Driver Board

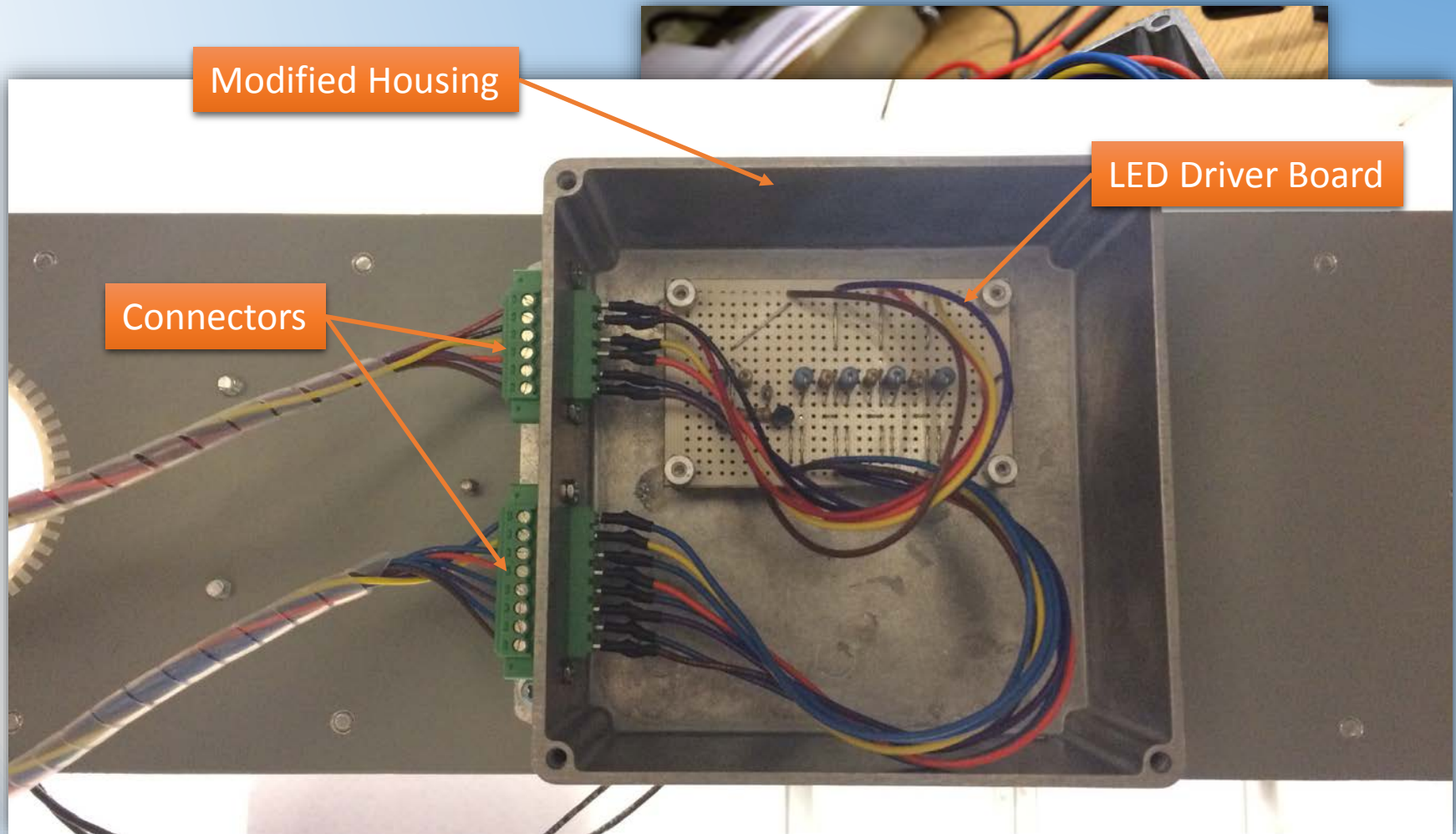
Modified Housing

Connectors



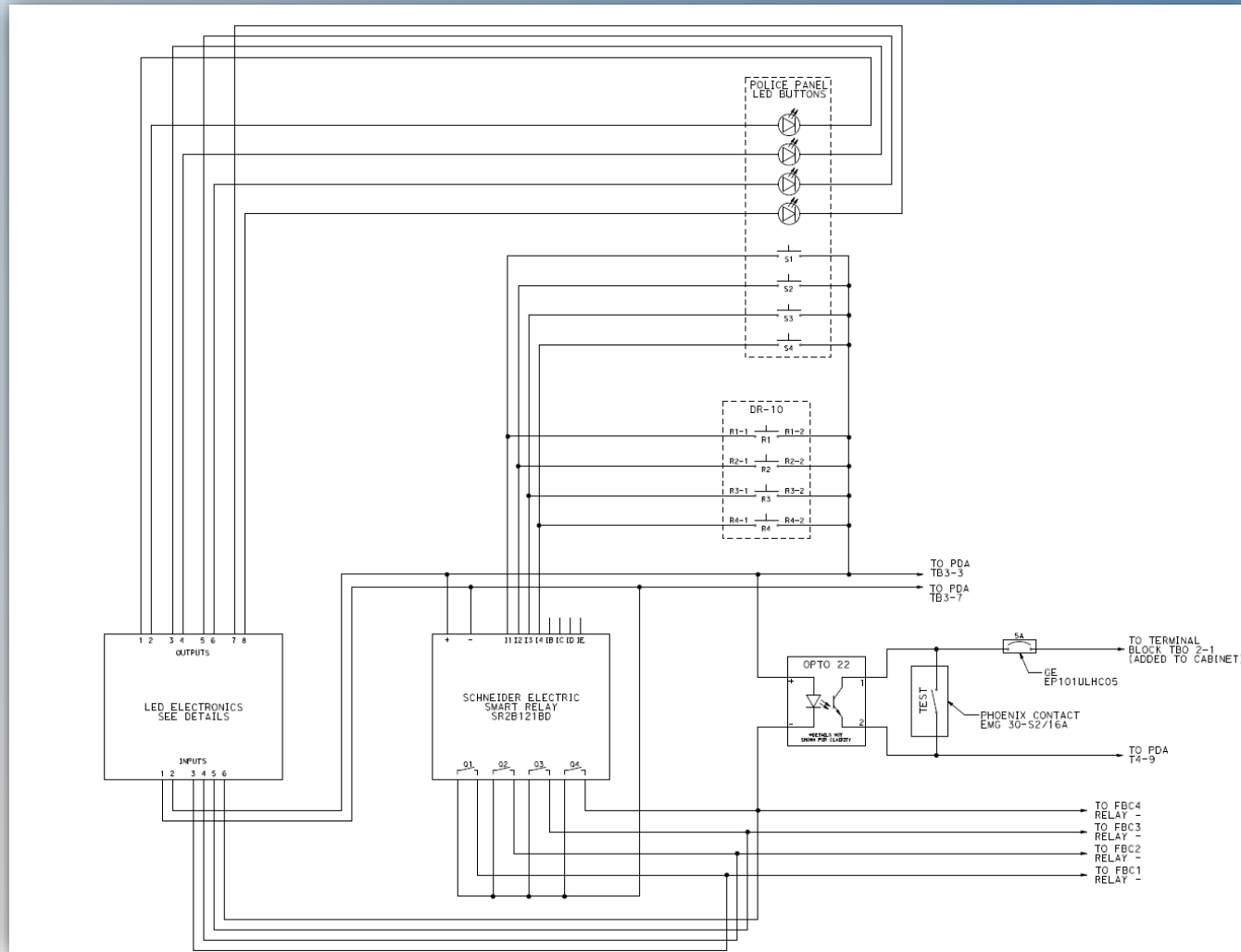
Controlling Electronics

Custom Electronics Box



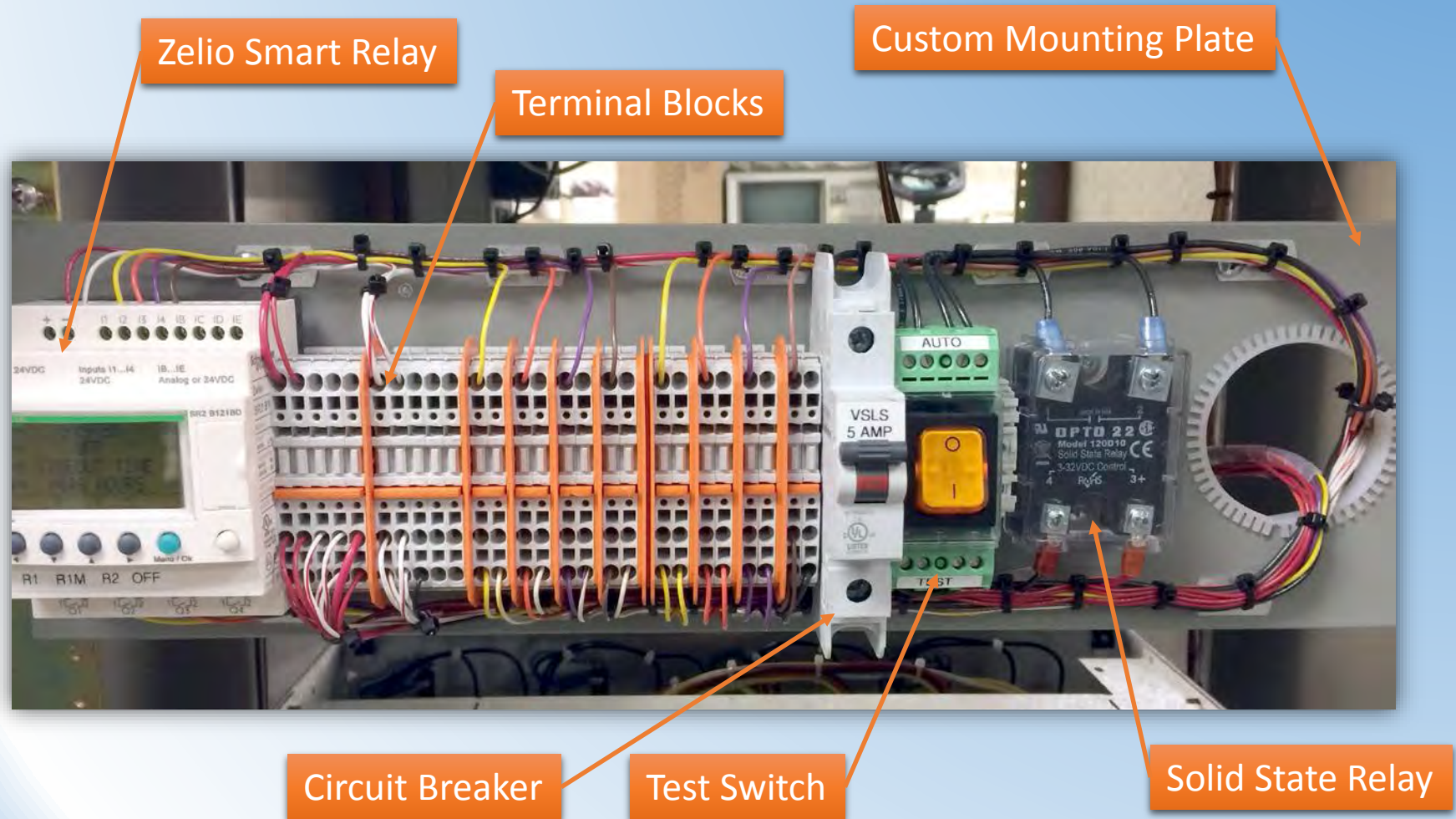
Controlling Electronics

System Schematic



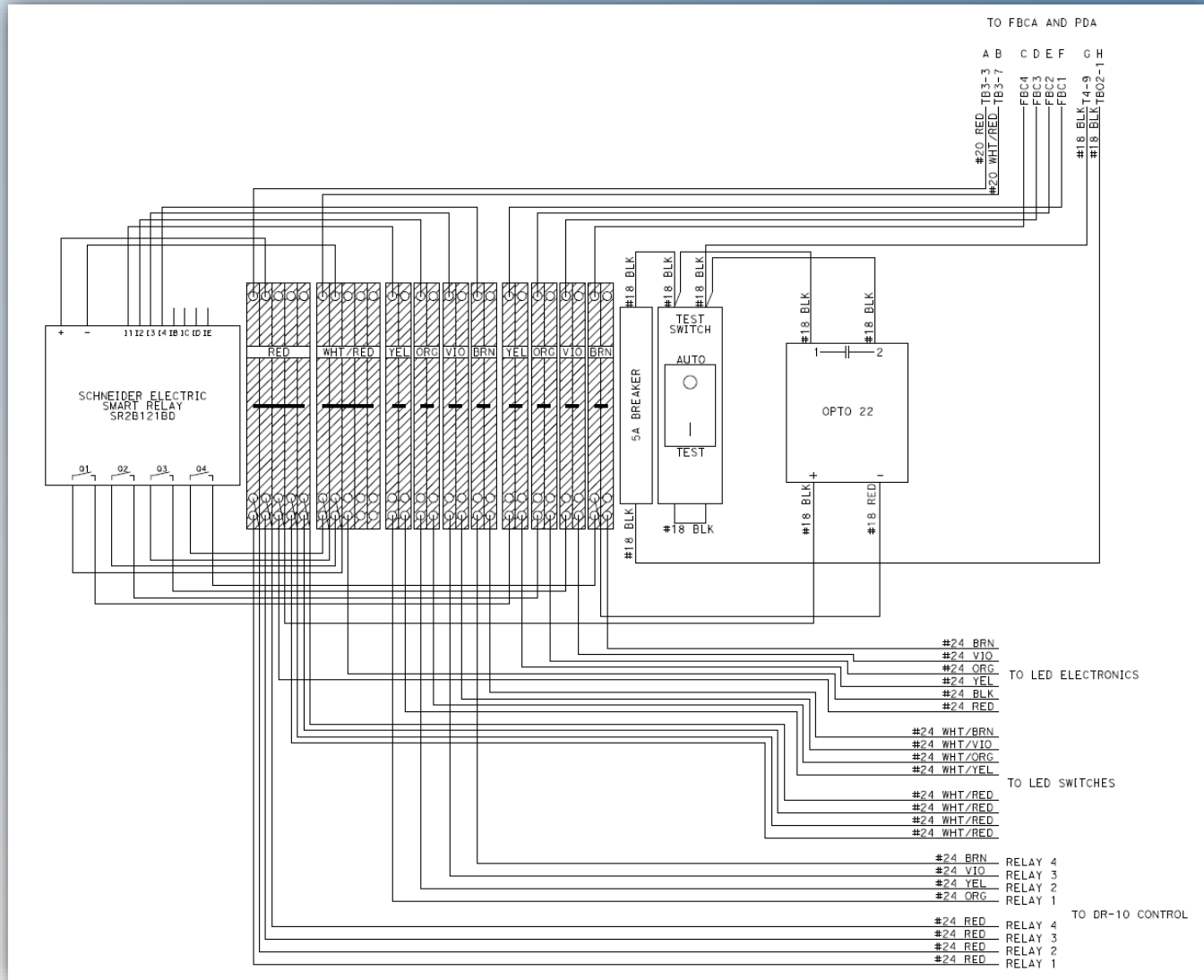
Controlling Electronics

Custom Mounting Plate

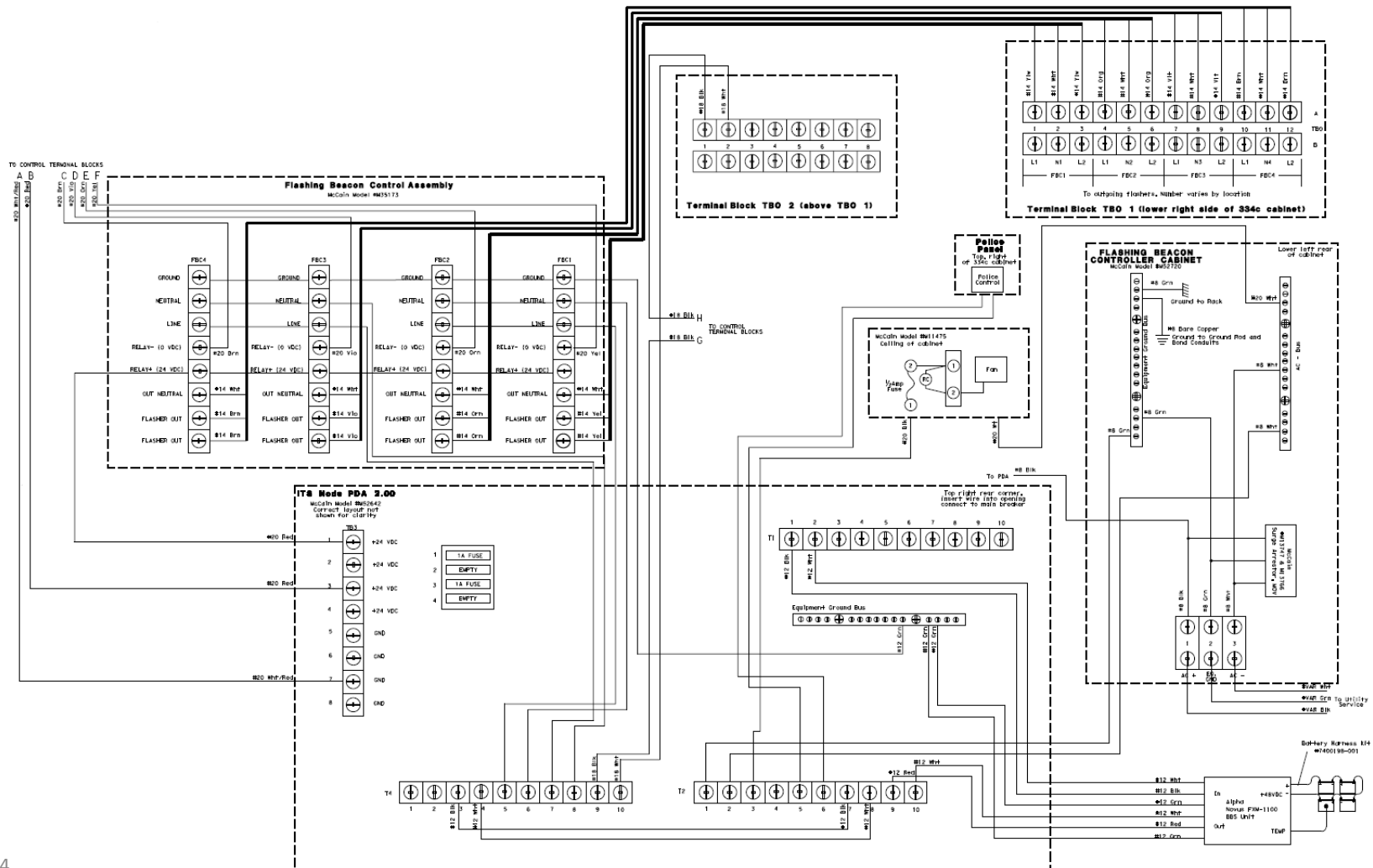


Controlling Electronics

Terminal Block Wiring Diagram



Controlling Electronics Cabinet Wiring Diagram



Battery Backup System



Battery Backup System

Inverter

- Alpha FXM 1100
 - Battery String Voltage: 48 V DC
 - Nominal Voltage: 120 V AC
 - Input
 - Voltage Range: 85-175 V AC
 - Current: 9.8 A
 - Frequency: 60/50 Hz
 - Output
 - Pure Sine
 - Voltage: 120 V AC
 - Frequency: Same as Input
 - Power: 1100 W



Battery Backup System

Batteries

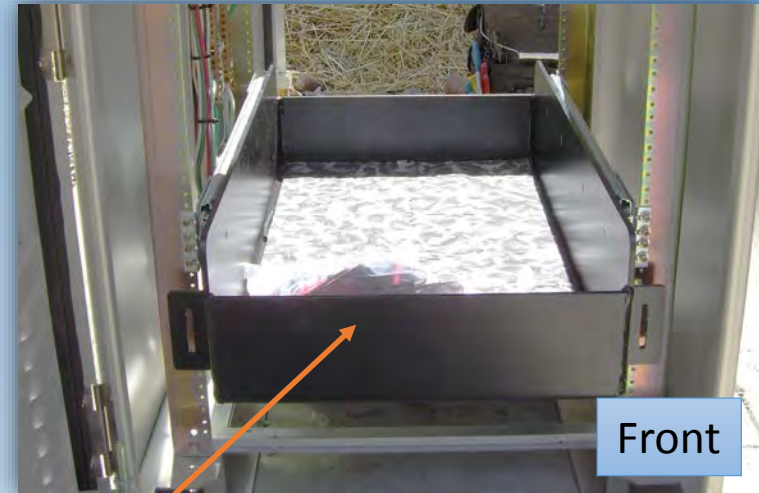
- C&D Technologies
Dynasty UPS12-300MR
 - Voltage: 12 V DC
 - Amp Hours: 78.6 AH
 - Absorbed Glass Mat (AGM)
 - Can be operated in any orientation



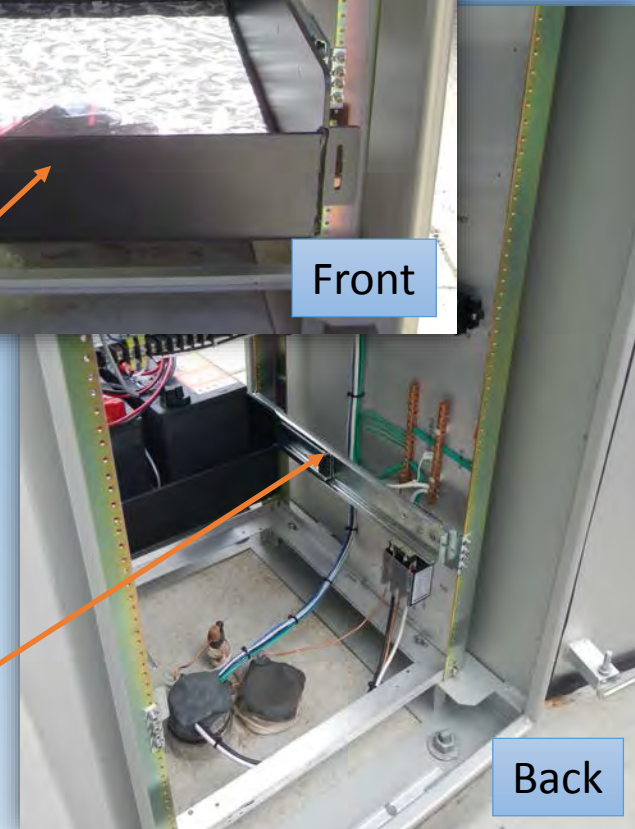
Battery Backup System

Battery Tray

- Custom designed battery tray
 - Holds 4 batteries
 - Holds up to 350 lbs
 - Slides out for ease of changing/testing batteries
 - Acid resistant powder coating

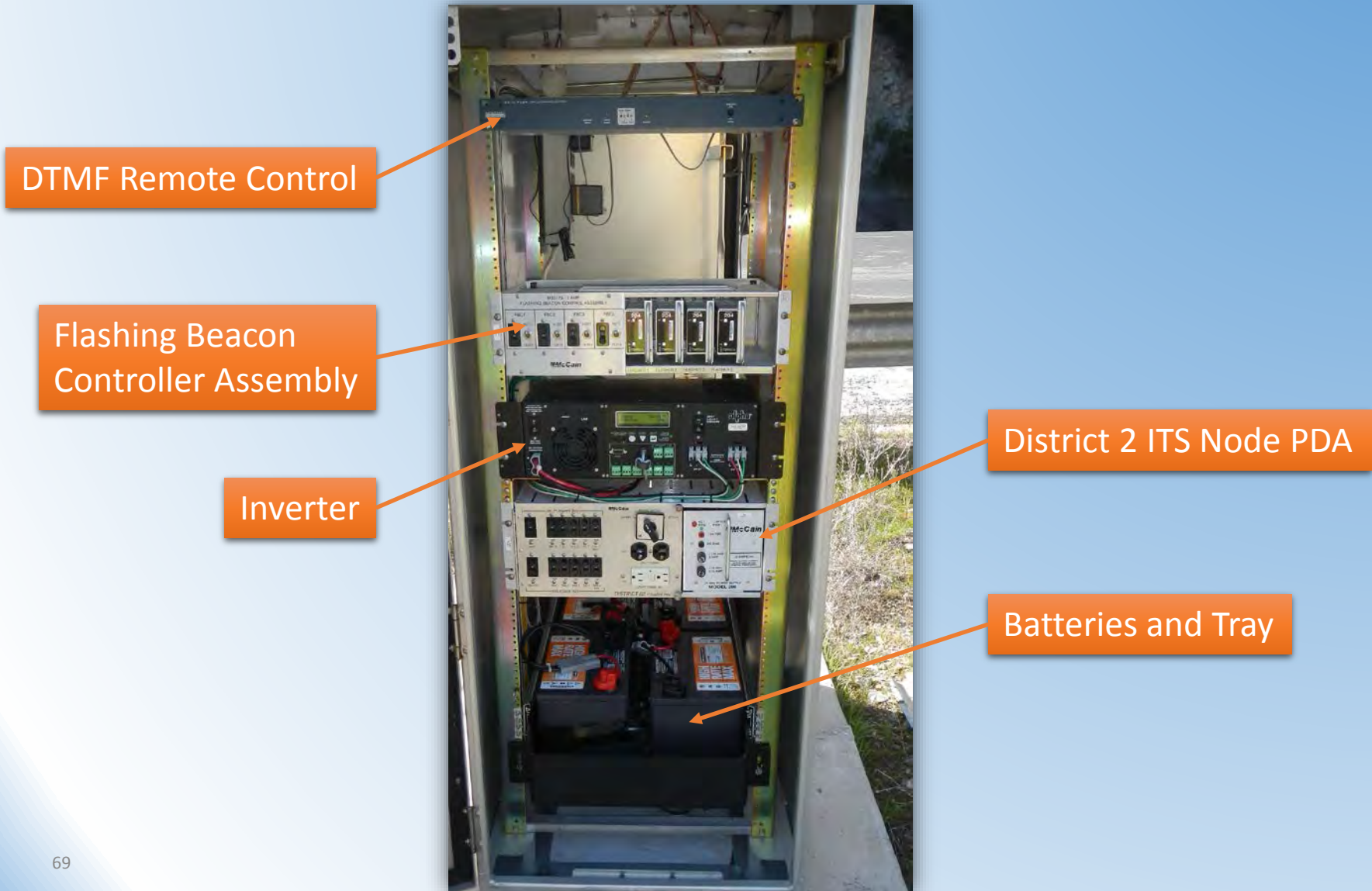


Battery Tray



Battery Tray Slides

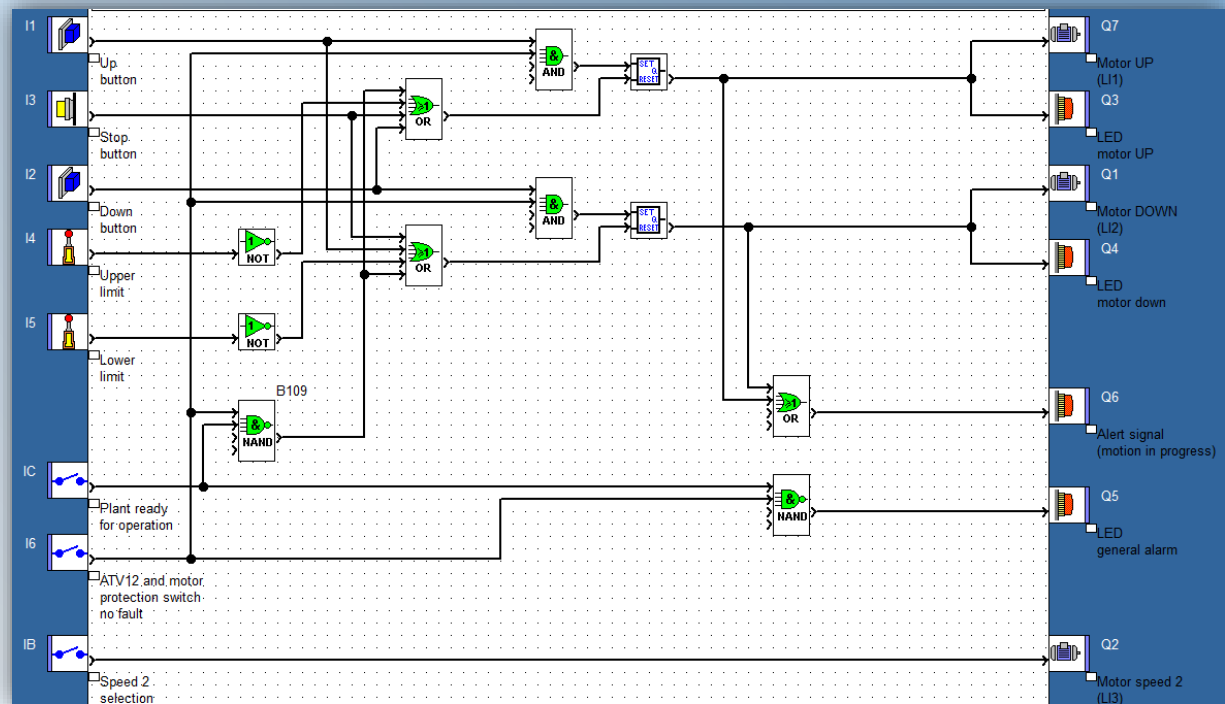
Flashing Beacon Controller Cabinet



Software

ZelioSoft Programming

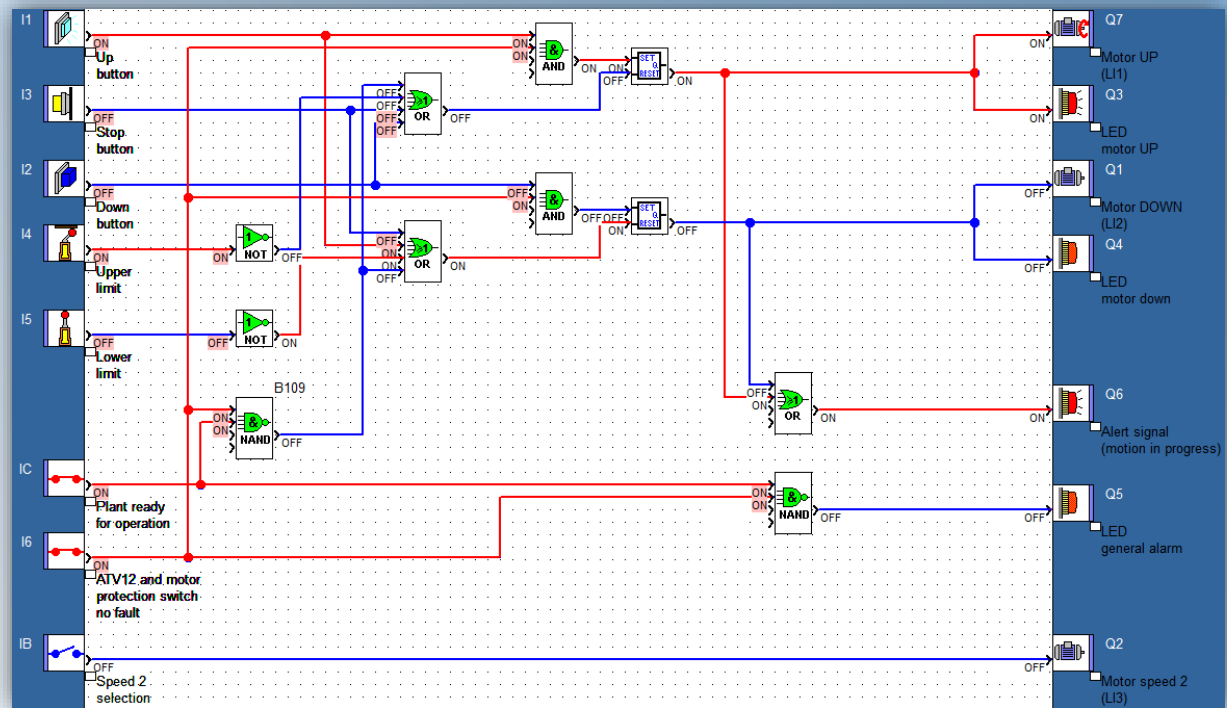
- Functional Block Diagram
 - Graphical programming based on predefined function blocks
 - Easy to understand without needing to know detailed programming language



Software

ZelioSoft Programming

- Simulation/Testing functionality is limited in programming suite
 - Cannot step through program
 - Cannot mimic real time inputs



Software

ZelioSoft Programming

- Inputs
 - Discrete (DISCR) Inputs
 - Filtered Discrete Input
 - Analog Input
 - Filtered Analog Input
 - Integer Input
 - Special Inputs in FBD Language
 - 10-Bit Integer Input

Software

ZelioSoft Programming

- Standard Functions
 - BOOLEAN Equation (Boolean function)
 - SET and RESET Function (RS switching)
 - PRESET COUNT Up/Down Counter
 - H-SPEED COUNT (Fast Counter)
 - UP/DOWN COUNT (Up/Down Counter)
 - TIMER A/C (Timer)
 - TIMER BW (Pulses on Edges)
 - TIMER Li (Cyclic Timing)
 - TIMER B/H (Time out)
 - COMP IN ZONE Comparison
 - PRESET H-METER (Preset Hour Counter)
 - TRIGGER (Schmitt Trigger)
 - COMP IN ZONE (Comparison of two values)
 - GAIN Function
 - DISPLAY (LCD Screen display)

Software

ZelioSoft Programming

- Standard Functions (Cont)
 - TEXT
 - TIME PROG (Daily, weekly, yearly programmer)
 - BISTABLE (Impulse Relay)
 - MUX (Multiplexing)
 - ADD/SUB (ADD/SUB Arithmetic Function)
 - MUL/DIV (MUL/DIV Arithmetic Function)
 - CAM BLOCK (Cam Programmer)
 - ARCHIVE
 - STATUS (Module Status)
 - CNA (Bit to Word Conversion)
 - CAN (Word to Bit Conversion)
 - SIn (Serial Port Input)
 - SOut (Serial Port Output)
 - COM (Message)
 - Sunrise/Sunset
 - Suntrack

Software

ZelioSoft Programming

- Sequential Function Charts Functions
 - Initial Step
 - Resettable initial step
 - Step
 - Divergence to AND
 - Convergence to AND
 - Divergence to OR
 - Convergence to OR

Software

ZelioSoft Programming

- Logic Functions
 - NO (NOT)
 - AND
 - OR
 - NO AND (NAND)
 - NO OR (NOR)
 - EXCLUSIVE OR

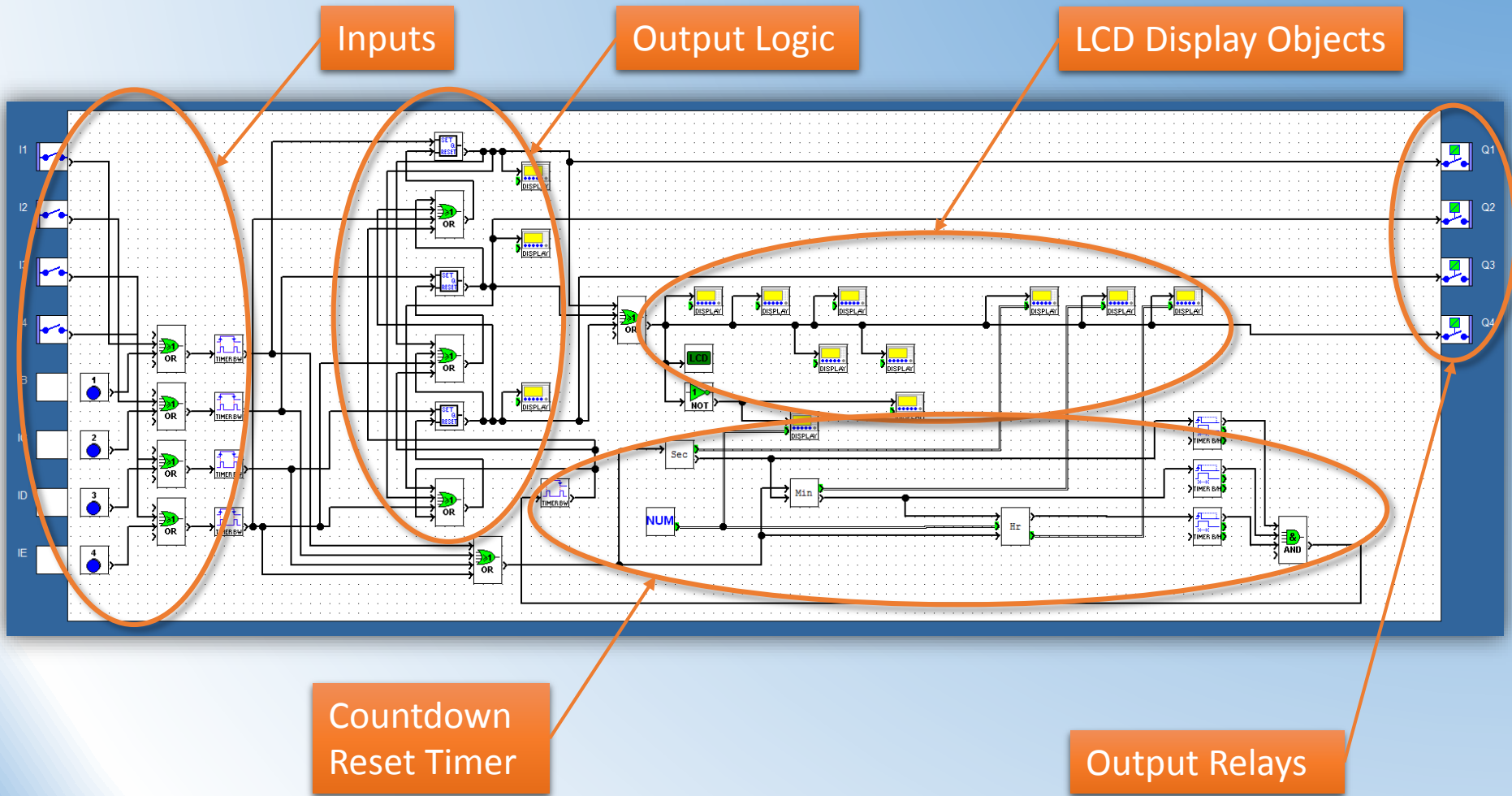
Software

ZelioSoft Programming

- Output Functions
 - Discrete (DISCR) Output
 - Integer Output
 - LCD Screen Backlighting Output

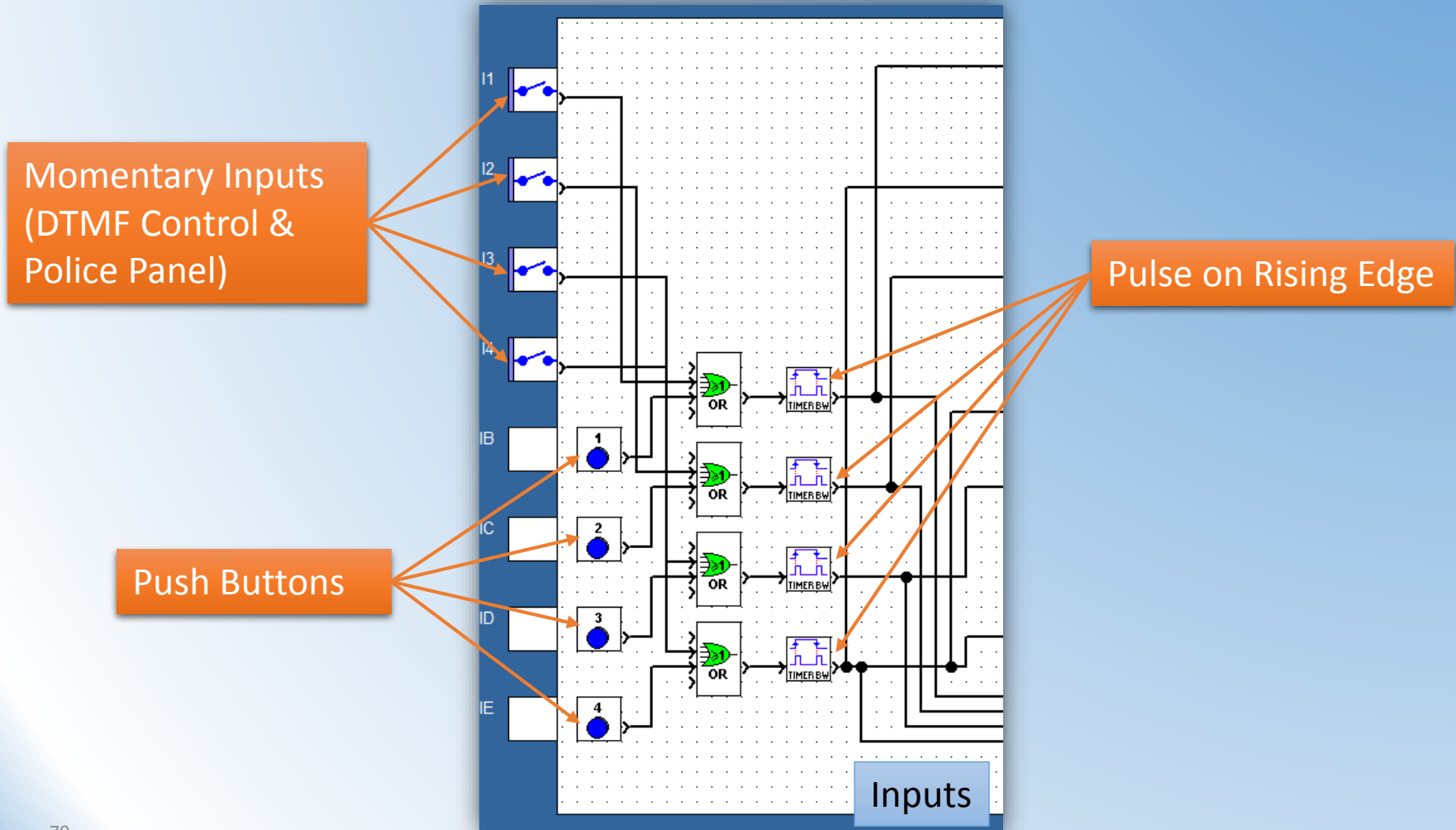
Software

ZelioSoft Programming



Software

ZelioSoft Programming

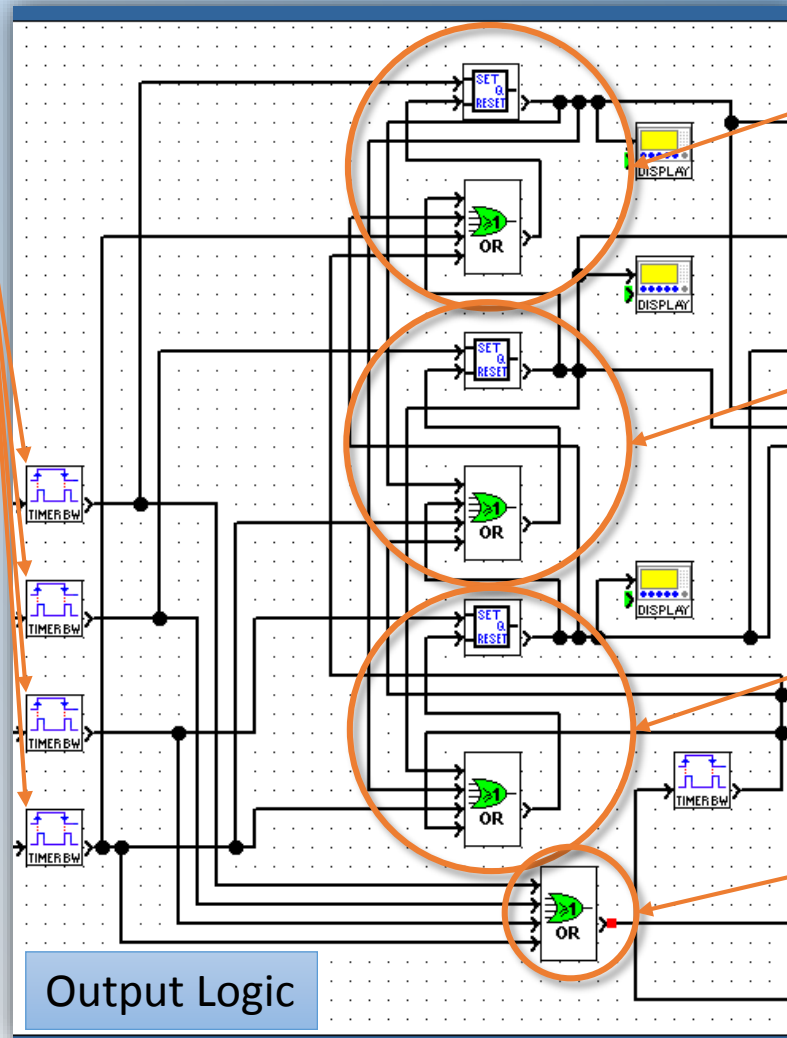


Software

ZelioSoft Programming

Pulse on Rising Edge

Input 1
Input 2
Input 3
Input 4 (Reset)



State 1 Logic

State 2 Logic

State 3 Logic

Countdown
Timer Reset

Output Logic

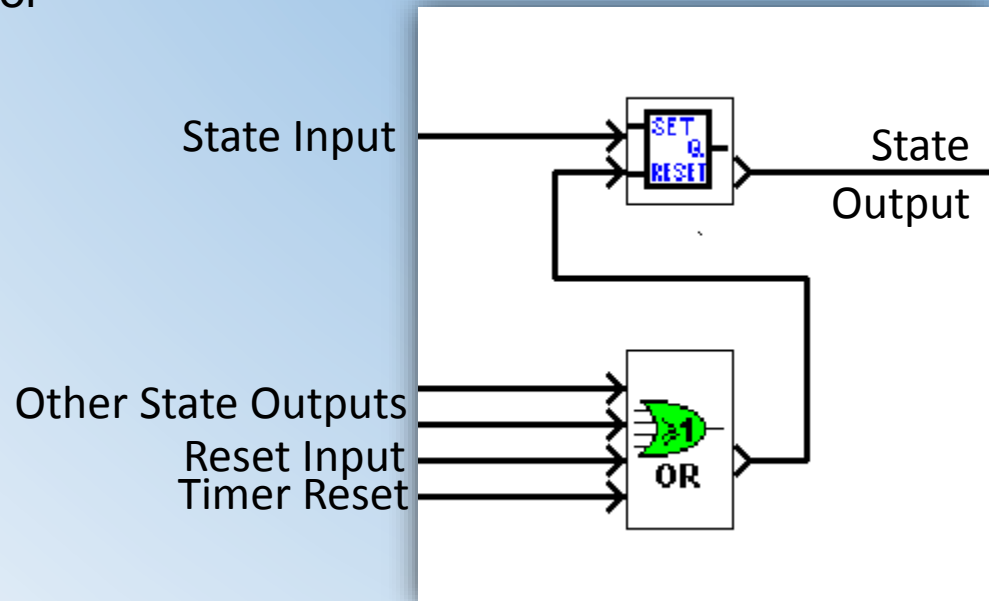
Software

ZelioSoft Programming

• How Each State's Logic Works

- Input State goes "high"
 - Output State turns on
- Input State goes "low"
 - Output does not change
- Other States, Reset, or Timer Reset goes "high"
 - Output State turns off

Truth Table					
Input	Other State A	Other State B	Reset	Timer Reset	Output
0	0	0	0	0	X
1	0	0	0	0	1
X	1	X	X	X	0
X	X	1	X	X	0
X	X	X	1	X	0
X	X	X	X	1	0



Software

ZelioSoft Programming

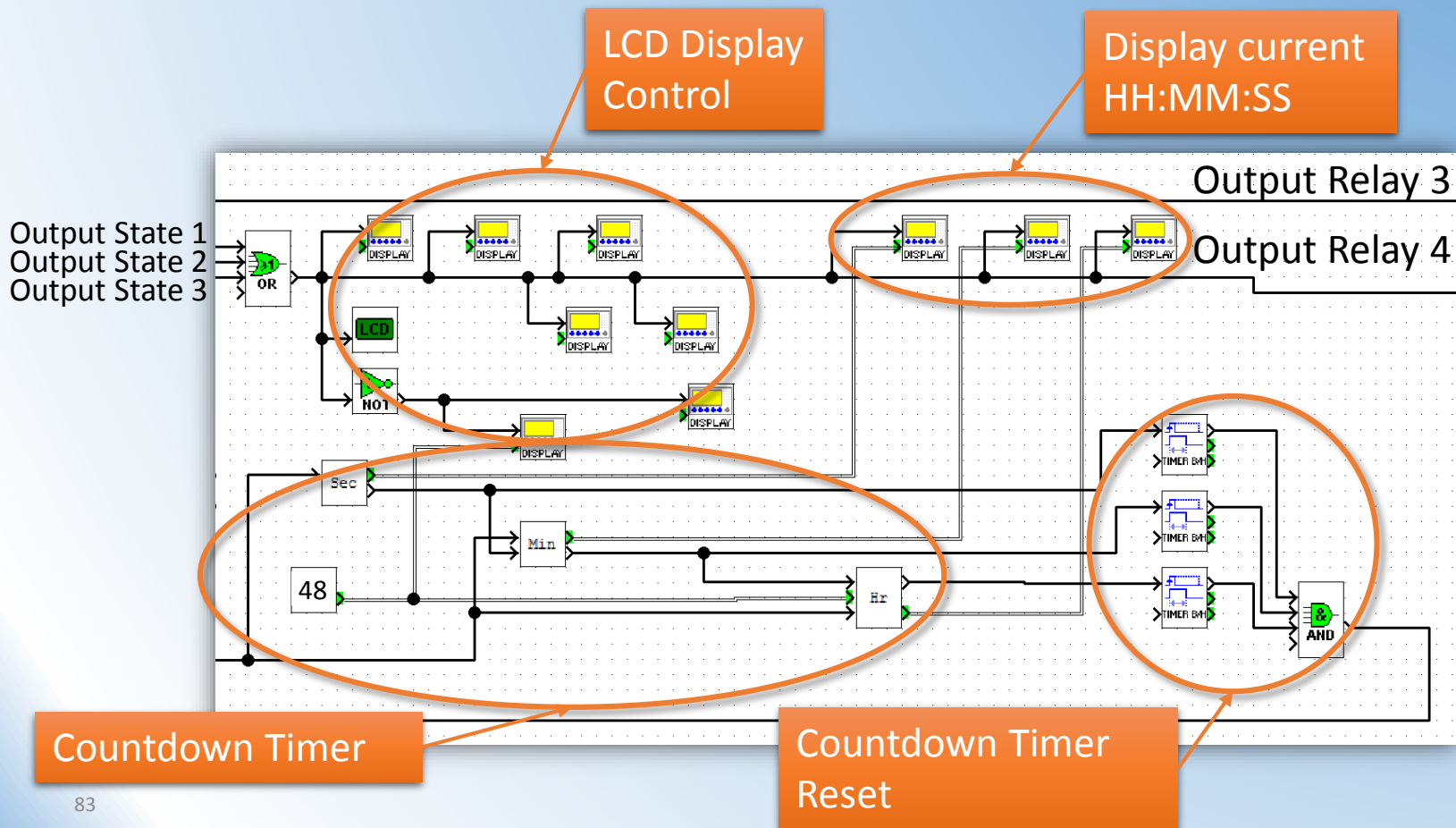
System Truth Table

Input 1	Input 2	Input 3	Input 4 (Reset)	Timer Reset	Output 1	Output 2	Output 3	Output 4
0	0	0	0	0	X	X	X	X
1	0	0	0	0	1	0	0	1
0	1	0	0	0	0	1	0	1
0	0	1	0	0	0	0	1	1
X	X	X	1	X	0	0	0	0
X	X	X	X	1	0	0	0	0

Software

ZelioSoft Programming

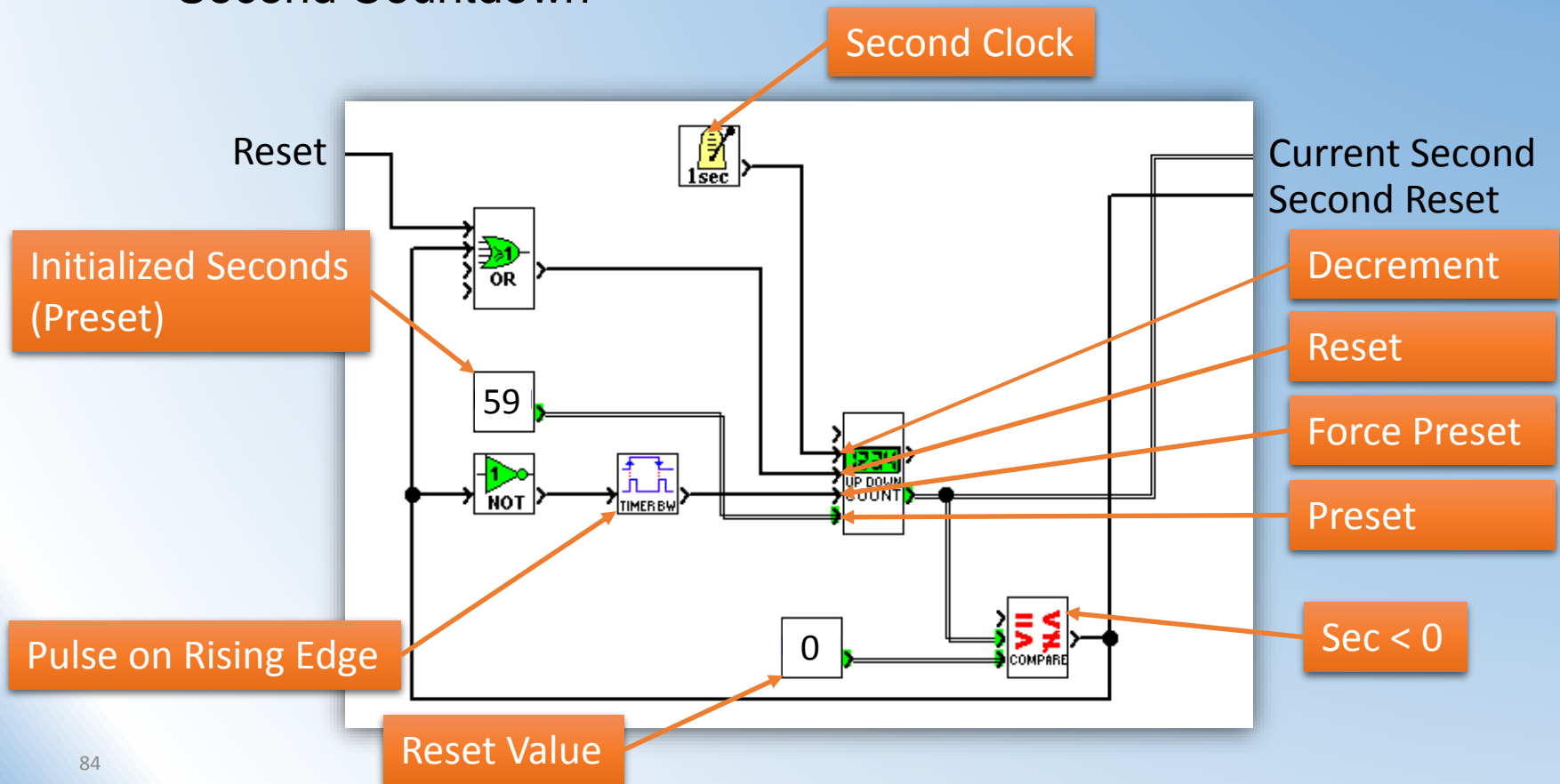
- How Countdown Timer Reset Works



Software

ZelioSoft Programming

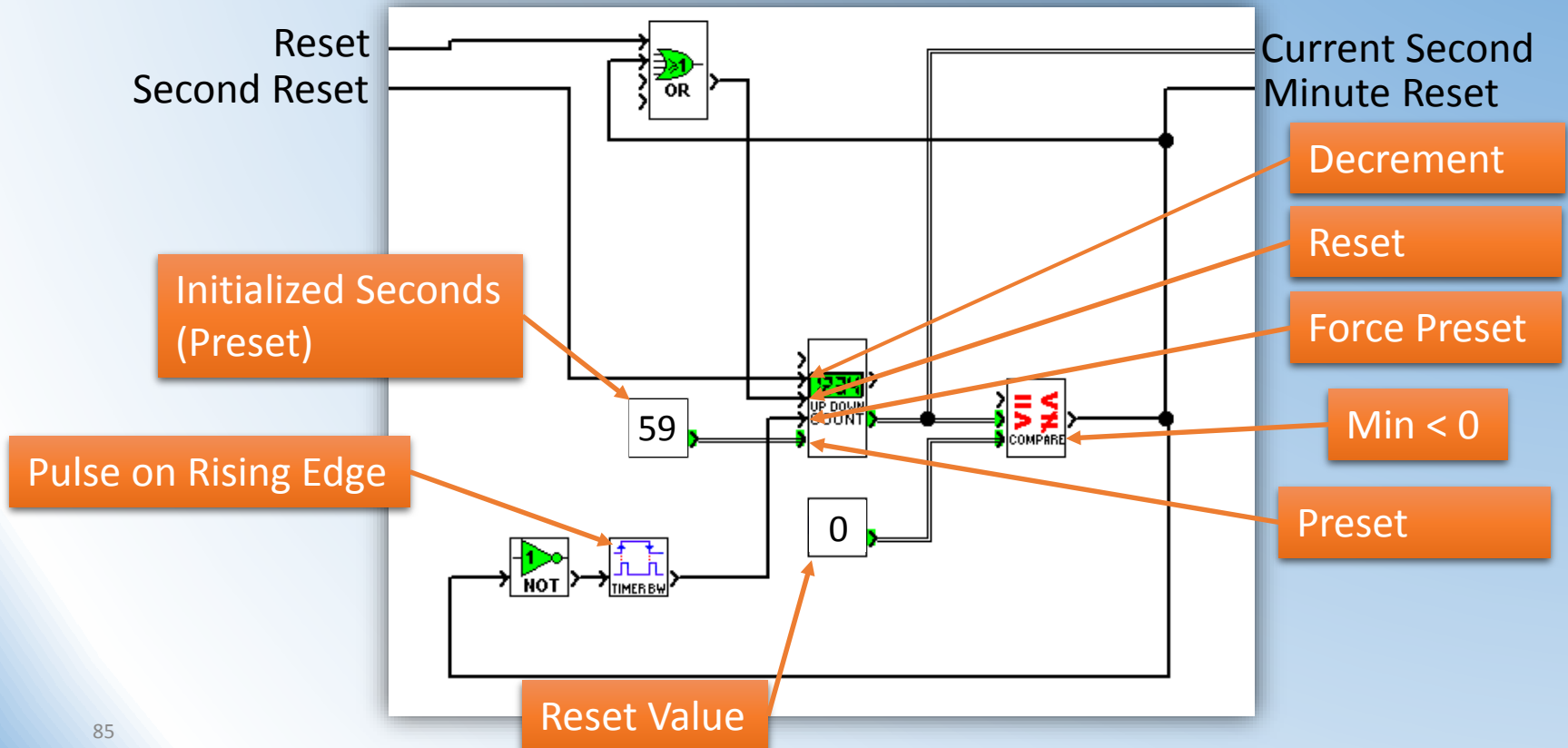
- Custom Logic Blocks
 - Second Countdown



Software

ZelioSoft Programming

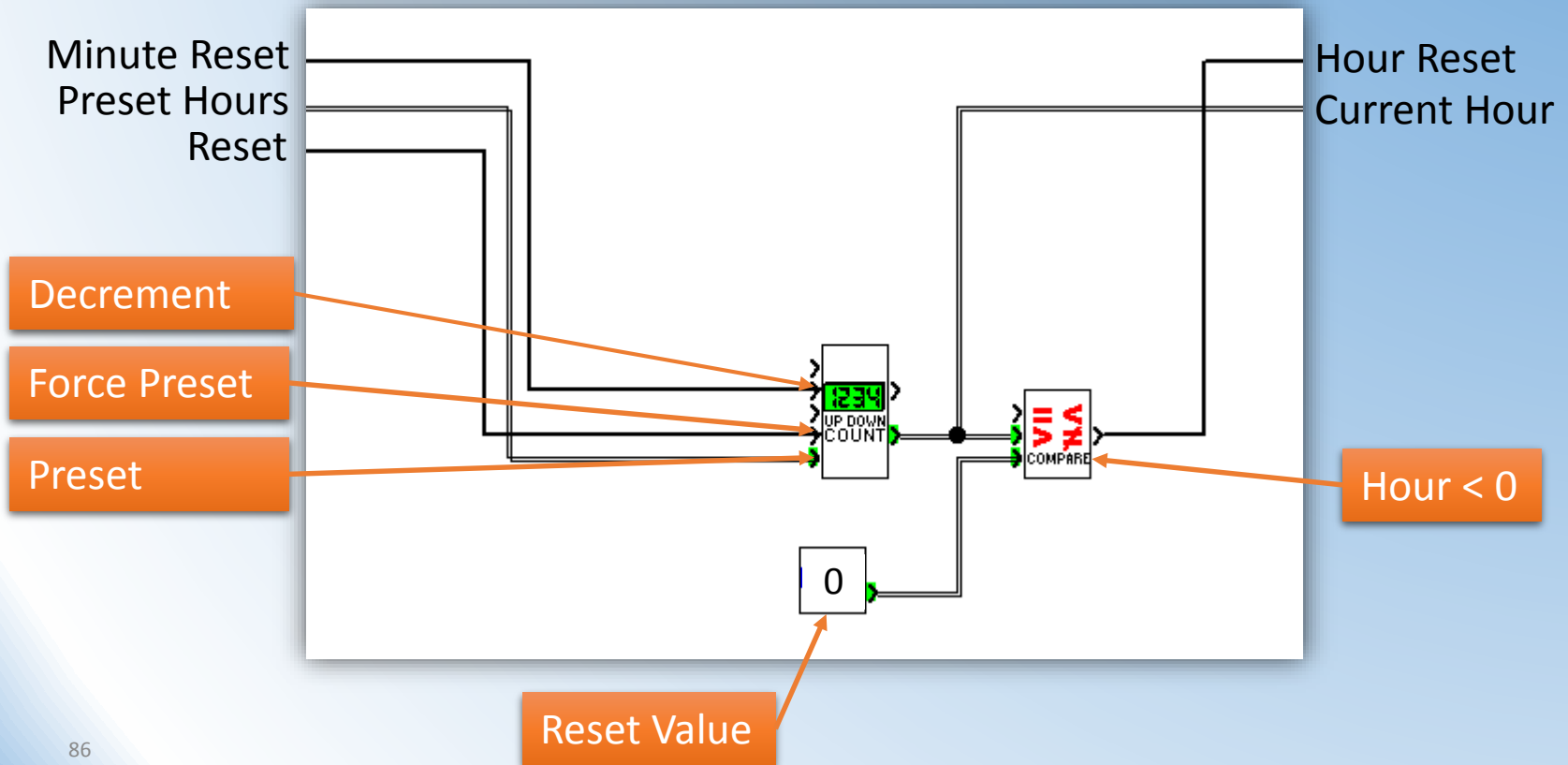
- Custom Logic Blocks (Cont)
 - Minute Countdown



Software

ZelioSoft Programming

- Custom Logic Blocks (Cont)
 - Hour Countdown



Deployment

Cabinet Wiring



Deployment

Cabinet Wiring



Deployment Cabinet Wiring



Functional Testing

- Steady Lit Condition vs Alternating Flashing Condition
 - Steady Lit does not catch eye
 - Alternating Flashing catches eye
 - Maintenance choose Alternating Flashing

Condition Active



Functional Testing

- Variable Speed Limit Sign has a “start-up” lag
 - Signs take approx. 10 seconds to show visible speed limit after system is turned on



Functional Testing

- Sign Text sizing
 - Feedback from local maintenance crew is that text size is too small
 - Text size is standard size used for chain control signs – 4”
 - Text size is too small for normal freeway speeds in good weather
 - Text is readable at 45-35 mph, typical speed during snowy conditions



Functional Testing

- Sign Lighting
 - Signs were not designed to have lighting
 - Testing at night time revealed the need for sign lighting.

Non-Lit Sign



Lit Sign

Operational Status

- System has been deployed
- Mild Winter
 - No snow has been present on Anderson Grade Pass to cause chain conditions
 - Could not monitor motorist behavior due to the mild winter
- Operations of Chain Control area has changed
 - Chain Control area is now manned during chain control events



Lessons Learned

- Variable Speed Limit Sign vs Extinguishable Message Sign
 - EMS would be better
 - Maintenance
 - Cost
 - Ease of integration
- Zelio Smart Relay
 - More inputs and outputs
 - More flexibility in adding and changing available conditions
- Add second Flashing Beacon Controller Assembly
 - Adds ability to have 8 controlled states



Lessons Learned

- Sign Lighting
 - Add Sign lighting
- Chain Condition Text Size
 - Increase size of text



Questions?

