Traffic Signal Preemption and Priority Technologies for Rail and Transit Applications

Aaron Littman, PE, PTOE
Eric Plapper
Safety Minute

- long wheelbases and low ground clearance aren’t always compatible with railroad crossings
Traffic Signal Preemption

- Preemption – the transfer of normal operation of a traffic control signal to a special control mode of operation (typically for railroad or emergency vehicles)

- Railroad applications
  - Purpose is to clear vehicles queued on nearby tracks
  - OMUTCD – Preemption for signals within 200’ of crossing; otherwise considered where queuing occurs over tracks
  - Signal should restrict movements that conflict with gate down
  - Requires active crossing warning system (flashers, gates) and interconnection
**Railroad Circuitry**

- DC, AC, AC-DC (Type C)
- Audio Frequency Overlay (AFO)
- Motion Sensor
- Constant Warning Time / Prediction (based on measured speed)

Failsafe: de-energized equipment/circuit failures result in active warning.
Traffic Signal Preemption

- Normal operation
Traffic Signal Preemption

- Normal operation
- Train approach
Traffic Signal Preemption

- Train detected (APT + 20 seconds min. warning time)
- Preemption initiated
Traffic Signal Preemption

- Preemption
  - Right-of-way transfer
Traffic Signal Preemption

- Preemption
  - Right-of-way transfer
  - Track clear
  - Flashing lights followed by lowering gates (MWT)
Traffic Signal Preemption

- Preemption
  - Right-of-way transfer
  - Track clear
  - Flashing lights followed by lowering gates (MWT)
  - Train arrives/dwell
Traffic Signal Preemption

- Train clears
- Return to normal operation
Traffic Signal Preemption

- Train clears
- Return to normal operation
Types of Railroad Preemption

- Simultaneous – notification to traffic signal controller and active railroad warning devices simultaneously (20 seconds minimum)
  - Usually not enough time to clear track before gate down

- Advanced – notification to traffic signal controller in advance of active railroad warning devices (limited to about 20 seconds)
Types of Railroad Preemption

- Advanced preemption
  (R/W transfer + queue clearance + separation time > railroad warning time)
- Longer distance = longer required warning time = greater cost
  - May need early termination of conflicting signal phases to work within available advanced preemption (typically pedestrian intervals)
  - Queue cutter (>~450’)
  - Pre-signal (not a substitute for preemption)
Anyone know what this is?
Traps

- Left turn trap
  - Opposing permissive left sees yellow ball during right of way transfer

- Solution
  - Terminate phases together
  - Use protected only left
Traps

- Preemption trap
  - Track clear phase ends before gates down

- Solutions
  - Use gate down circuit
  - Track clear >>> APT
Preemption Circuitry and Equipment
Interface Panel (ODOT SS 819/919)

- Interconnection Circuits – 6-pair
  - Advanced Preemption
  - Simultaneous Preemption
  - Island Occupied
  - Gate Down
  - Gate Up (future Advanced Pedestrian Preempt circuit utilizing pre-notification from CWT system).
  - Traffic Signal Health – notifies railroad of conflict flash or power failure.
Preemption Circuitry and Equipment
Interface Panel (ODOT SS 819/919)

- Each circuit has a test switch

- Supervisory circuit on preemption circuit
  - 1 opened, 1 closed = detects short or break
  - Failure = signal flash

- Preemption timer
  - 10 minutes max.
  - Time out = signal flash
  - Returns to normal operation if preemption ends
Preemption Circuitry and Equipment

Indicator Panel

- Typically on signal pole nearest and facing railroad bungalow
- Same circuit status indications shown on interface panel
- Standardized layout
Preemption Circuitry and Equipment
Vital Inductive Loop Detection (ODOT SS 810/910)

- Advanced processor monitors, analyzes, and adjusts parameters to maintain proper tuning
- Utilizes second check loop to periodically simulate vehicle presence
- Often uses durable preformed loop
Preemption Circuitry and Equipment

- Compliant signal controller
- Applicable signs
- Uninterruptable Power Supply (UPS)
- Cabinet warning labels
Powell Queue Cutter Signal

- Regular queues from signalized intersection about 850’ to east
Powell Queue Cutter Signal

- Too far for preemption / intersection constrained, too costly to add capacity
Powell Queue Cutter Signal

- Parallel parking and left turns onto Depot Street also created queuing
Powell Queue Cutter Signal

- Before
Powell Queue Cutter Signal

- Restricted turns at Depot Street
- Signal heads/stop line on EB SR-750
- Two sets of vital loop detector pairs (signal / midblock queuing)
- Any one detector occupied for programmed time will trigger red phase
- Preemption triggers track clearance phase followed by dwell in red
Powell Queue Cutter Signal

- Operational Spring 2016
- Initial settings were triggering red signals too frequently and unnecessarily
  - Loops installed incorrectly / replaced with preformed
  - Initial detector delays were keyed in incorrectly
- Still had similar issues after corrections (although less severe)
  - Made repeated observations
  - Detector delay and extension refined (unique for each detector)
  - Interval times adjusted
- Balancing safety and efficiency (and perception)
Fremont Signal Preemption
Fremont Signal Preemption

Revised curb and drainage to accommodate relocated gates / better defined approach

Additional signal phases for increased efficiency and preemption

Truncated domes on sidewalk at tracks

Relocated crossing provides better pedestrian visibility

Pedestrian island shortens new pedestrian crossing (lower APT)
Fremont Signal Preemption
Fremont Signal Preemption

**PHASING DIAGRAM**

**LEGEND**

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>VEHICLE $\Phi$</td>
<td>$\rightarrow$</td>
</tr>
<tr>
<td>PERMITTED $\Phi$</td>
<td>$\cdots$</td>
</tr>
<tr>
<td>PEDESTRIAN $\Phi$</td>
<td>$\cdots$</td>
</tr>
</tbody>
</table>

**Phasing States**

- $\Phi_1 & \Phi_5$
- $\Phi_2 & \Phi_6$ (RECALL)
- $\Phi_3 & \Phi_7$
- $\Phi_4 & \Phi_8$

**Phasing Details**

- OLA (EB LT) = $\Phi_5 & \Phi_9$
- OLB (NB RT) = $\Phi_1 & \Phi_8$ (DISABLED IN RRPE)
- OLC (WB LT) = $\Phi_01 & \Phi_{10}$
- OLD (WB TH) = $\Phi_0 & \Phi_{10}$
- OLE (WB RT) = $\Phi_07 & \Phi_{10}$
- OLF (EB TH) = $\Phi_02$ (DISABLED IN RRPE)
- NLT = NO LEFT TURN SYMBOL / "TRAIN"
- NRT = NO RIGHT TURN SYMBOL / "TRAIN"