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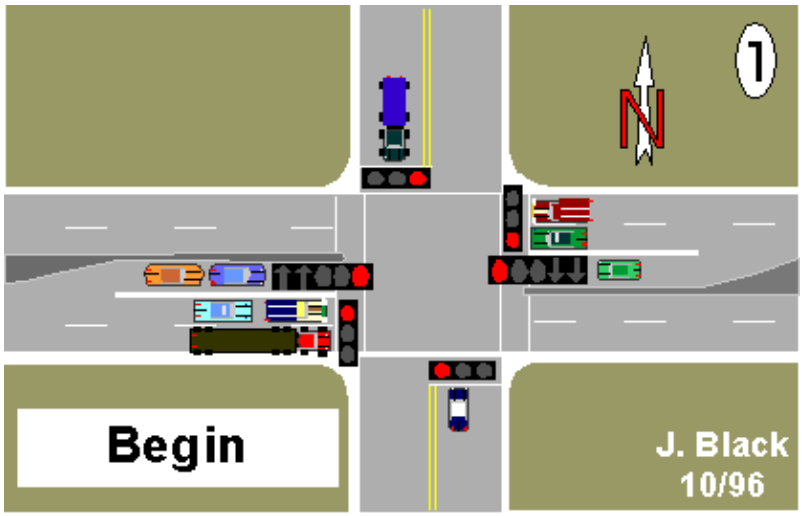
TecNote 3013
How to Use "Inhibit Phases" to Avoid the "Yellow Trap"

"Inhibit Phases" can be used in place of "anti backup" external controller logic to insure that the controller never "backs into" a protected left-turn phase causing the "yellow trap" safety problem.



The "Yellow Trap" During Dual-Lead Left-Turn Sequences

Many agencies do not use lead/lag left-turn sequences with protected/permissive left-turn displays because of the "yellow trap" issue. However, this policy does not insure that the "yellow trap" is always avoided because the "trap" can also occur with dual left-turn sequences when the cross street phases are skipped.

Compare the following lead/lag and dual-lead left-turn sequences where:

- five section left-turn displays are used for the protected/permitted display
- ø1 and ø5 provide the protected (turn-arrow) indications
- ø2 and ø6 provide the permitted (green ball) indications in the 5-section display

Case 1 - Vehicle Calls Exist On All Phases

Lead/Lag Left-turn Sequence	Dual-Lead Left-Turn Sequence
ø1 + ø6 (phase 1 leads) ø2 + ø6 (dual thru movement) lead turn "trapped" as ø6 clears to ø5 ø2 + ø5 (phase 5 lags) ø3 + ø7 ø4 + ø8 ..... ø1 + ø6 (phase 1 leads)	ø1 + ø5 (dual-lead left-turn) ø2 + ø6 (dual thru movement) permitted turns end at same time NO "yellow trap" ø3 + ø7 ø4 + ø8 ..... ø1 + ø5 (dual-lead left-turn)

Case 2 - Vehicle Call On Phase 5 When Phase 1 and Cross Street is Skipped

Lead/Lag Left-turn Sequence	Dual-Lead Left-Turn Sequence
ø1 + ø6 (phase 1 leads) ø2 + ø6 (dual thru movement) lead turn "trapped" as ø6 clears to ø5 ø2 + ø5 (phase 5 lags) SKIP ø3 - ø4 - ø5 - ø7 - ø8 ..... ø1 + ø6 (phase 1 leads)	ø1 + ø5 (dual-lead left-turn) ø2 + ø6 (dual thru movement) SKIP ø3 - ø4 - ø1 - ø7 - ø8 ..... left turn "trapped" as ø6 clears to ø5 when phase 1 is skipped ø2 + ø5 (phase 5 lags)

From this example, we see that the "yellow trap" can occur with dual-lead left-turn sequences as well as lead/lag left-turn sequences under the right conditions. Any controller can "back into" a protected left-turn phase when the cross street phases and the opposing left-turn are skipped. Therefore, a policy of avoiding lead/lag left-turn sequences does not always insure the "yellow trap" is avoided.

How to Avoid the "Yellow Trap" During Any Left-Turn Sequence

Naztec, Inc. offers these guidelines to point out controller features that can be used to deal effectively with the "yellow trap" issue. Naztec, Inc. assumes no liability for the use or application of any information presented in these TecNotes related to the "yellow trap" issue.

"Inhibit Phases" is a Naztec controller feature which prevents (or inhibits) a phase from being serviced if another specified phase is on. In the dual-lead example above, the "yellow trap" can be avoided if ø5 is programmed as an *"Inhibit Phases"* for ø6. This prevents the controller from "backing into" ø5 following ø6 when the cross street is skipped. *"Inhibit Phases"* are programmed from the Main Menu using key sequence, MM->1->1->5 as follows:

```
              Inhibit Øs  1111111
Ø ..Call.Øs.. 12345678  90123456
1   0 0   0   0 ........  ........
2   0 0   0   0 X.......  ........
3   0 0   0   0 ........  ........
4   0 0   0   0 ..X.....  ........
5   0 0   0   0 ........  ........
6   0 0   0   0 ....X...  ........
7   0 0   0   0 ........  ........
8   0 0   0   0 ......X.  ........
```

Lagging Left-turn Sequences

Keep in mind that *"Inhibit Phases"* also prevent the controller from running any lead/lag left-turn sequences. If you apply a lagging left-turn sequence when the lagging turn is "inhibited", the lagging turn phase will be skipped each cycle unless you lift the "Inhibit Phase" for this movement..

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Recommended Guidelines for Lagging Left-turn Sequences

1. You should only apply a lead/lag left-turn sequence if the leading left-turn display is protected only or you are using a left-turn signal display to avoid the yellow trap (this will vary for each agency).

2. If both opposing left-turn displays are protected-only, you should only apply a dual lag/lag left-turn sequence if max calls are placed on the through phases and min recalls are placed on the left-turn phases to insure that the lag turns begin simultaneously - otherwise you could create a yellow trap situation if one of the protected left-turn phases is skipped.

General Rule to Avoid the Yellow Trap

Using standard 8-phase operation, if you inhibit ø1 with ø2, ø3 with ø4, ø5 with ø6 and ø7 with ø8, you will insure that the "yellow trap" never occurs in a protected/permitted left-turn display. You can safely lag a left-turn phase by following this rule:

Lift the "Inhibit Phase" if the opposing left-turn is protected only

Detector Switching And "Inhibit Phases"

Detector switching extends the through the permissive left-turn indication in a left-turn display when the protected indication is red by extending the adjacent through phase with a left-turn call detector. If your system has a mixture of protected only and protected/permissive left-turn displays, you should remember to apply inhibit phases and switch detectors correctly.

Inhibit Phase / Detector Switching Example

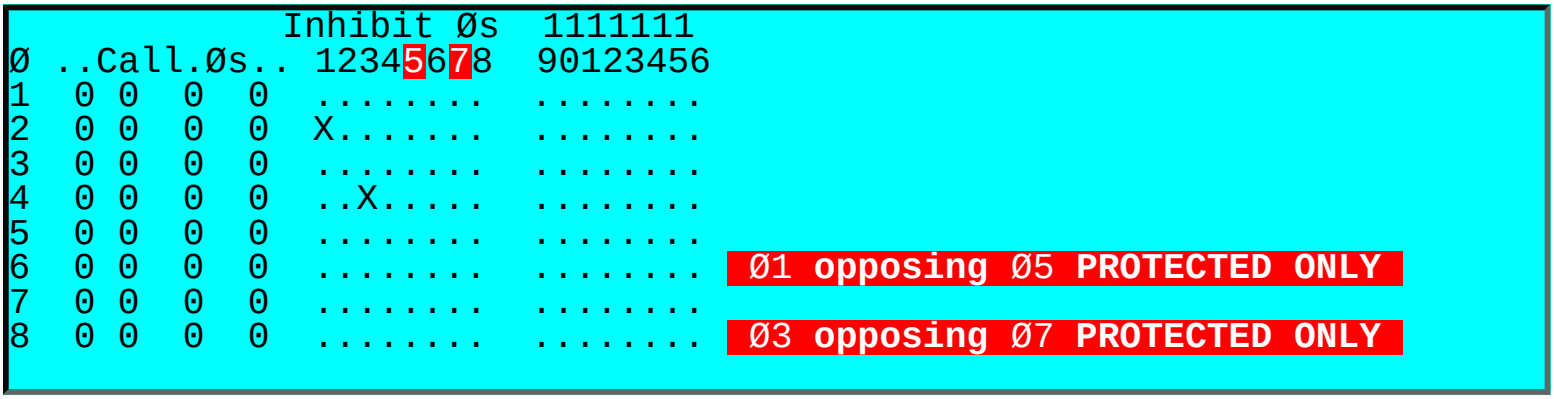
Suppose a particular intersection uses a combination of protected-only and protected/permitted left-turn turn displays. In this example:

- ø1 and ø3 are protected only
- ø5 and ø7 also have a permitted left-turn display

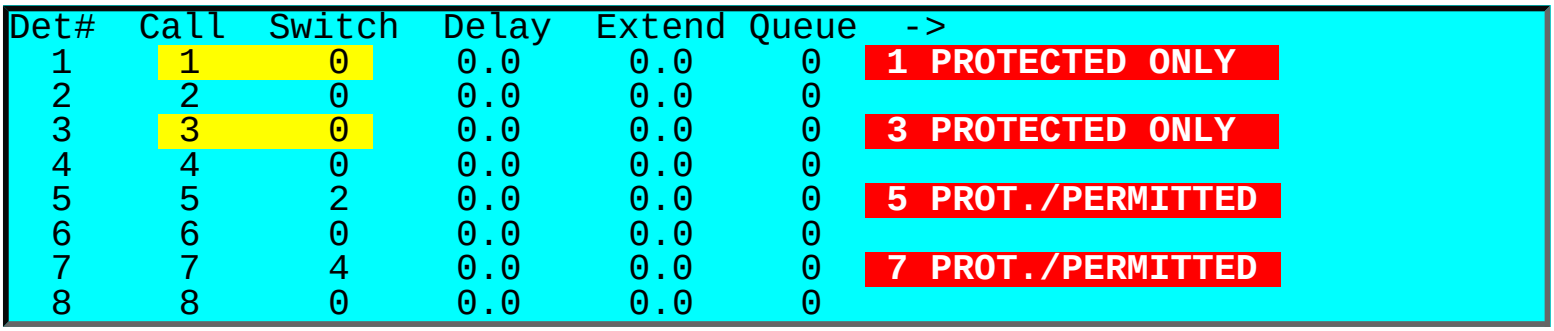
Assuming "Inhibit Phases" are a default for phases 1-3-5-7, let's apply the general rule above:

Lift the "Inhibit Phase" if the opposing left-turn is protected only

In this example, ø1 and ø3 are protected only, so you need to lift the *"Inhibit Phases"* for the opposing through phases (ø2 and ø4). Phases ø5 and ø7 are protected/permitted, so you need to inhibit these phases when the opposing through movement is green to prevent the controller from "backing into" these phases when the cross street is skipped:



You also need to remove any detector switching for the protected only movements serviced by ø1 and ø3. Here is the controller database for this example under main menu MM->5->1:



Detector switching allows left-turn detectors to extend the permitted left-turn display only when protected left-turn phase is red and adjacent thru phase is green.

- Detector #1 calls ø1
- Detector #3 calls ø3
- Detector #5 calls ø5 and switches the call to extend ø2 when ø5 is red and ø2 is green
- Detector #7 calls ø7 and switches the call to extend ø4 when ø7 is red and ø4 is green

Detector switching is only needed when the left-turn is protected/permitted, not when the left-turn is protected-only because there is no permitted left-turn display. Detector switching should only be used to extend the permitted indication in a protected/permitted left-turn display.

Detection Considerations When the Cross Street is Skipped

"Inhibit Phases" prevents the "yellow trap" by inhibiting (or suppressing) the left-turn phases while the main street phases are being serviced. This prevents the protected-only left-turn phases from being serviced before a cross street

phase is serviced. But what about the situation when the cross street is skipped for several cycles during coordination and the left-turn demand exceeds the available gaps for the permitted movement?

If this a concern, you can easily program a delay detector sourced by the left-turn detector to place a min call on the cross street. After the adjustable delay times out, the cross street is serviced for a min green time before cycling to the protected left-turn phase.

In this database template, detectors 61 - 64 are "sourced" by detectors 1, 3, 5 and 7 from controller menu, MM->5->3:

Det#	Occ:	G	Y	R	Delay.PS	Mode	Src
61		.	.	.	0	0 NORMAL	1
62		.	.	.	0	0 NORMAL	3
63		.	.	.	0	0 NORMAL	5
64		.	.	.	0	0 NORMAL	7

Make sure that detectors 61 - 64 are programmed to "Call" but NOT to "Extend" using controller menu MM->5-> 2. We want these delay detectors to recall the cross street, but not extend it.

Det#	Call	Extend	Queue	Add.Init	->
61	X	.	.	X	
62	X	.	.	X	
63	X	.	.	X	
64	X	.	.	X	

In controller menu MM->5->1 below, detectors 61 - 64 place artificial calls on the opposing street after a 100 second delay. Just remember that detectors 61-62-63-64 are sourced by left-turn detectors 1-3-5-7 so that:

- detectors 61 and 63 (detectors 1 and 5) call the opposing street (phase 4)
- detectors 62 and 64 (detectors 3 and 7) call the opposing street (phase 6)

Det#	Call	Switch	Delay	Extend	Queue	->
61	4	0	100.0	0.0	0	
62	2	0	100.0	0.0	0	
63	4	0	100.0	0.0	0	
64	2	0	100.0	0.0	0	

NRM_RR Detector Mode Option

You can use a new detector mode option in place of this artificial side street call that services Red Rest to terminate the through movements before reservicing the protected turn phases. This method reduces delay if the cross street is serviced without a call. The NRM_RR detector mode is found under MM->5->3.

Det#	Occ:	G	Y	R	Delay.PS	Mode	Src
61		.	.	.	0	0	NRM_RR	1
62		.	.	.	0	0	NRM_RR	3
63		.	.	.	0	0	NRM_RR	5
64		.	.	.	0	0	NRM_RR	7

You can easily observe this detector delay operation with a Naztec controller and a NEMA tester (or Naztec TestBox). Just place constant calls on ø2 and ø6, then place constant calls on ø1 or ø5 and observe that the *"Inhibit Phases"* prevent the controller from "backing into the turns". After 100" with no calls on 3-4-7-8, a min call is placed on ø4 to create a buffer between the end of ø2 and ø6 and left-turn phases ø1 and ø5. If you use the NRM_RR method, the detectors call *Red Rest* after the delay times out. This effectively reservices the turns when the cross street is skipped without causing the "yellow trap".

Adjusting the Delay Detectors For Protected-Only Left-Turn Phases

In the last section we disabled detector switching when ø1 and ø3 left-turns were protected-only. The delay detectors discussed in this section also need to be disabled to avoid recalling the cross street needlessly. Just remember that the detector sequence 61-62-63-64 corresponds with sourced detectors 1-3-5-7. If any left-turn phase is protected, it's associated delay detector should be disabled as the example when ø1 and ø3 left-turns are protected-only.

Det#	Call	Switch	Delay	Extend	Queue	->
61	0	0	100.0	0.0	0	
62	2	0	100.0	0.0	0	
63	0	0	100.0	0.0	0	
64	2	0	100.0	0.0	0	

"Redirect Ø Calls" Guarantees a Permissive Indication

The Naztec controller software also provides a feature called *"Redirect ø Calls* that guarantees a left-turn vehicle will receive a permissive indication when the adjacent through movement is skipped.

For example, a cross street is controlled by phases 3-4-7-8 with protected/permitted left displays used for all left-turn movements. Suppose the right-of-way is transferred to the cross street when a left-turn driver is detected on ø3. If dual-entry is programmed for ø4 and ø8, the controller will enter the cross street in ø3 and ø8.

Now, suppose a left-turn driver places a call on ø7 without a call on ø4. The controller cannot "back into" ø7 (protected display) because there is an *"Inhibit Phase"* on ø7 while ø8 is on to prevent the "yellow trap". The driver will not receive a permitted turn display serviced by ø4 because ø4 is being skipped. So, in this case, the controller will continue to service ø3 and ø8 until gap-out occurs. The driver on ø7 will be forced to wait until the next cycle because the "Inhibit Phase" was applied to prevent the "yellow trap". Detector switching cannot resolve this issue because the call on ø7 cannot switch to ø4 unless ø4 is green.

"Redirect ø Calls" resolves this problem and guarantees that the left-turn driver on ø7 is given a permissive indication

even if the adjacent through movement is not called. The following defaults for *"Redirect ø Calls"* (MM->1->1->5, right screen) are suggested for all protected/permitted left-turn signal indications to avoid skipping the permitted left-turn indication when the adjacent through movement is skipped:

Redirect ø Calls (from ø to ø)									
ø	From	To	From	To	From	To	From	To	From	To
1	0	0	0	0	0	0	0	0	0	0
2	1	6	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0
4	3	8	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0
6	5	2	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0
8	7	4	0	0	0	0	0	0	0	0

In our example, these *"Redirect ø Calls"* insure that ø4 adjacent to ø7, will receive a call whenever a vehicle is detected on ø7 and the opposing through movement (ø8) is green. *"Redirect ø Calls"* will reduce citizen complaints about the cross street being "skipped".

Conclusions

The "yellow trap" safety issue can be avoided if you build *"Inhibit Phases"* into your default database template and are careful to remove these inhibits when lagging left-turns can be used safely. As long as *"Inhibit Phases"* are properly applied, it is impossible to create a "yellow trap" condition even if an incorrect lead/lag left-turn sequence is selected. This method provides a high degree of risk management dealing with this issue.

"Detector Switching" can be used to extend the permissive portion for protected/permitted left-turn displays and should be avoided if the left-turn display is protected only. Assigning additional delay detection can be used in situations when there aren't enough gaps to service the demand during the permitted interval and the side street is skipped. *"Redirect ø Calls"* allows a left-turn detector to call an adjacent through phase to service the permitted left-turn display when the adjacent through phase is skipped. These features further enhance controller operation when *"Inhibit Phases"* are used to prevent the "yellow trap".