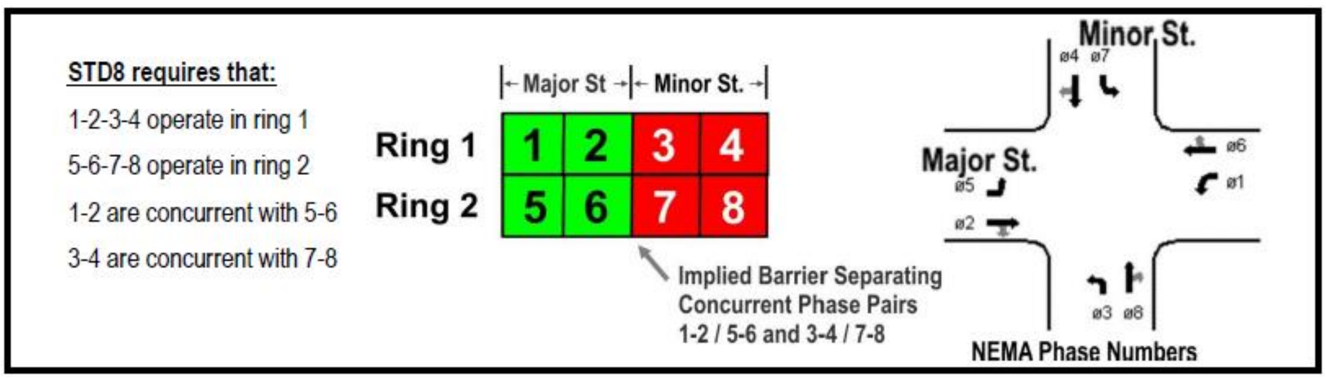
Tech Note 1117 – Lead / Lag Phasing Considerations

This Tech Note will discuss Lead / Lag phasing engineering considerations when running non-coordinated, coordinated and Synchro Green intersections and corridors. This document references the FHWA Traffic Signal Timing Manual (FHWA-HOP-08-024) and the Transportation Research Record 1324: Guidelines for Use of Leading and Lagging Left-Turn Signal Phasing.

Phasing and Lead / Lag left turn Phasing Overview

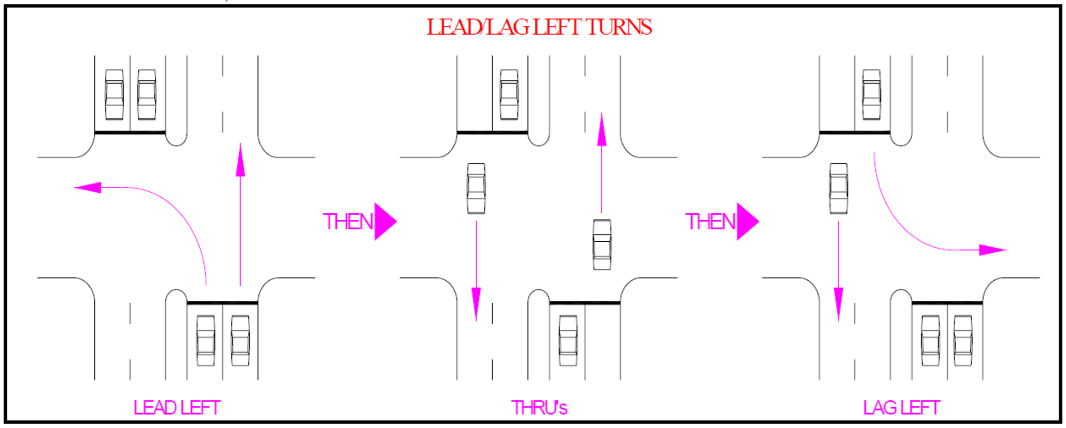
Most traffic signals apply STD8 operation even if all eight phases are not enabled. NEMA assigns the left-turn movements to the odd-numbered phases and the through movements to the even numbered phases. It is easy to remember this convention if you recall that the even numbered through phases are assigned in a clockwise manner (2-4-6-8) and the left-turn phases opposing each thru are numbered in pairs 1-2, 3-4, 5-6 and 7-8. Many agencies assign phase 1-2-5-6 to the major (coordinated) street and 3-4-7-8 to the cross street as shown below. Other agencies assign phases to a direction (north, south, east or west) if the non-intersecting streets in the network are parallel.



When operating an intersection, the agency must consider all movements of traffic including left turn movements. Intersection layouts are based on many factors including geometry, user characteristics (trucks, cars pedestrians), user demand, measured volumes, capacity and critical movement analysis.

Left turns at intersections have long been a source of concern for traffic engineers. In recent years, greater traffic volumes at many intersections and fiscal and right-of-way constraints on construction have led traffic engineers to design and implement increasingly sophisticated signal schemes to allow vehicles to turn left safely and efficiently.

Left turns can be protected or permissive. Protected left turns can be leading or lagging the thru traffic as shown below.



The permissive scheme is the most common type of signal scheme accommodating left turns in the United States. In this scheme, vehicles may turn left when receiving the green-ball signal and when sufficient gaps appear in the opposing traffic stream, which also has a green-ball signal. In another very common signal scheme, the protected scheme, vehicles may turn left only when receiving a green-arrow signal, which affords them exclusive right-of-way through the intersection. In most applications, the protected signal is given to vehicles turning left before the green ball is given to the through movement on the same street (i.e., protected leading). In most applications, the protected signal is given to vehicles turning left before the green ball is given to the through movement on the same street (i.e., protected leading). Most other common signal schemes to accommodate eft-turning vehicles involve a variation on or combination of permissive and protected schemes, including:

• Protected-lagging, in which the green arrow is given to left-turning vehicles after the through movements have been serviced;

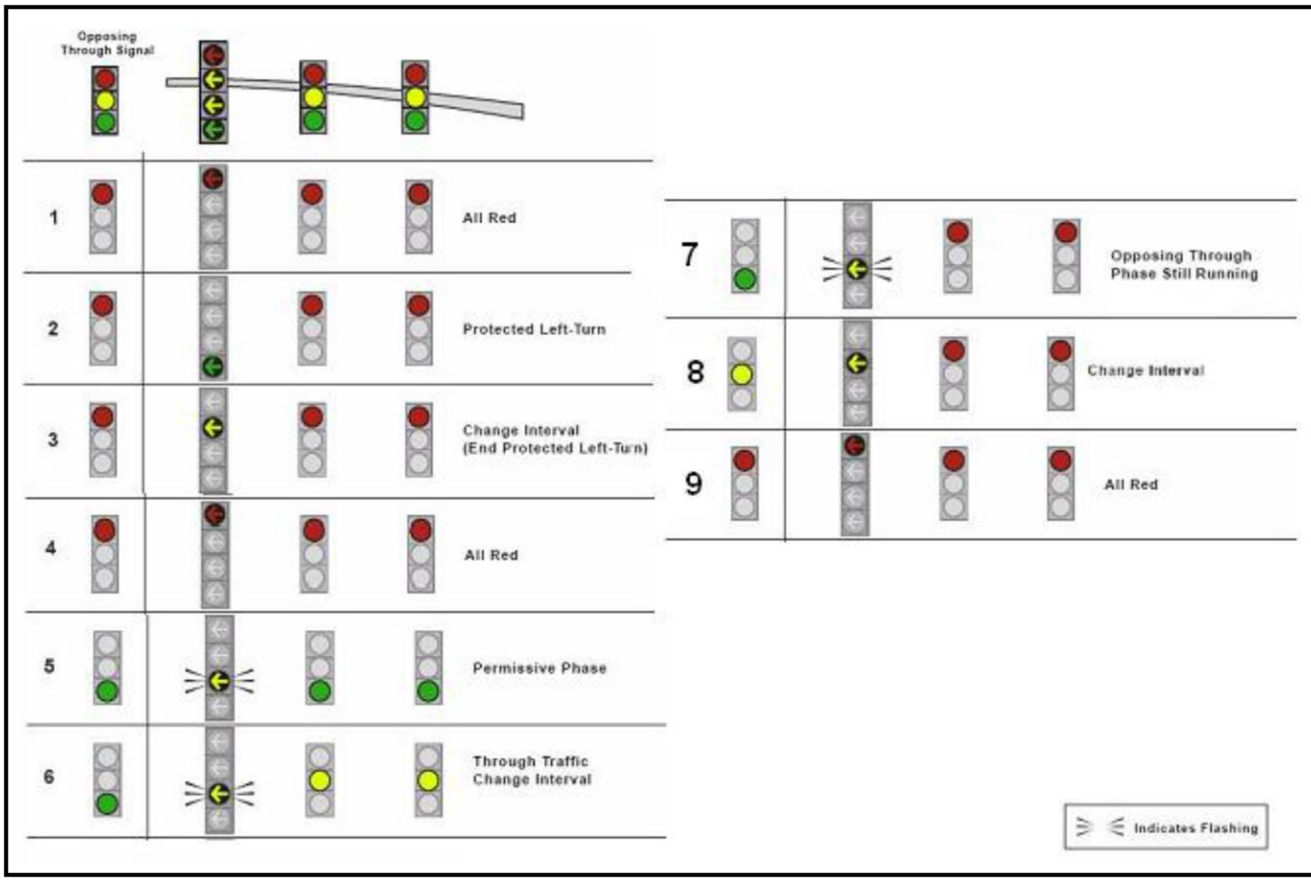
• Protected-permissive, in which protected left turns are made first in the cycle and a green-ball signal allows permissive left turns later in the cycle; and

•Permissive-protected, in which permissive left turns are allowed first in the cycle and protected left turns are accommodated later in the cycle.

Based on the needs of the agency, the engineer can choose when they want left turns to run. In standard 8 phase mode there are 16 different sequences, that can be chosen to satisfy all lead and lag left turn combinations.

Seq #	Phase Seq.
1	1 2 3 4 5 6 7 8
2	1 2 3 4 6 5 7 8
3	2 1 3 4 5 6 7 8
4	2 1 3 4 6 5 7 8
5	1 2 3 4 5 6 8 7
6	1 2 3 4 6 5 8 7
7	2 1 3 4 5 6 8 7
8	2 1 3 4 6 5 8 7
9	1 2 4 3 5 6 7 8
10	1 2 4 3 6 5 7 8
11	2 1 4 3 5 6 7 8
12	2 1 4 3 6 5 7 8
13	1 2 4 3 5 6 8 7
14	1 2 4 3 6 5 8 7
15	2 1 4 3 5 6 8 7
16	2 1 4 3 6 5 8 7

Many agencies choose to use a flashing yellow arrow, for left turns, to warn and control the permissive left.



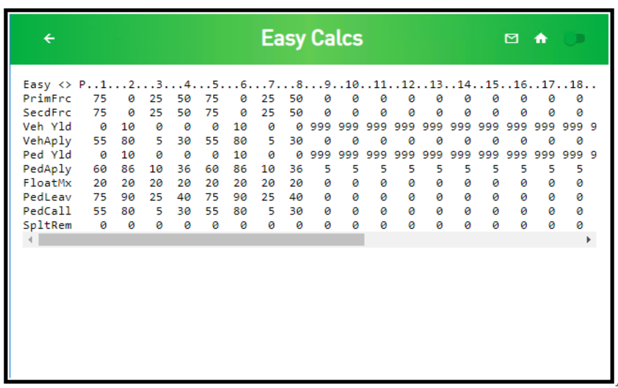
Once an agency determines how to set up their intersections, they may want to operate them in free or coordinated modes. Lead /Lag lefts are normally engineered for the best traffic flow during Free operation (fixed recalls or actuated detection). When a user operates signals in coordination they may use lead/lag phasing to improve green band efficiency. In addition, because SynchroGreen adaptive uses coordination as its basis, it could also be impacted.

Controller Software Decision Considerations

Once an agency chooses how to set up their intersections, they may want to operate them in free or coordinated modes. As explained above setting up coordination creates an additional layer of engineering.

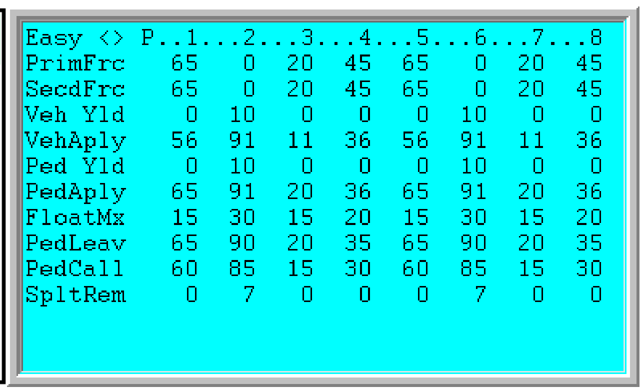
Coordination Parameter Calculations

When an agency sets up Coordination for a set of intersections, the controller software will calculate how to split up the cycle for each phase movement. The user can review these calculations using the **Easy Calcs** screen at **MM-2-8-2**.

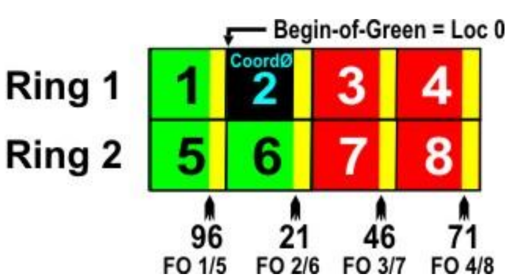


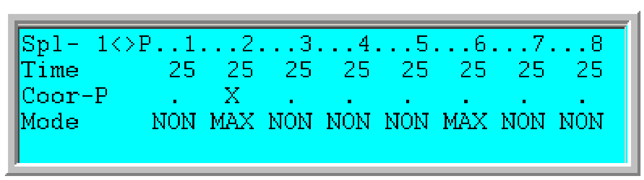
Easy Calcs

Easy <> P	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
PrimFrc	75	0	25	50	75	0	25	50	0	0	0	0	0	0	0	0	0	0
SecdFrc	75	0	25	50	75	0	25	50	0	0	0	0	0	0	0	0	0	0
Veh Yld	0	10	0	0	0	10	0	0	999	999	999	999	999	999	999	999	999	999
VehAply	55	80	5	30	55	80	5	30	0	0	0	0	0	0	0	0	0	0
Ped Yld	0	10	0	0	0	10	0	0	999	999	999	999	999	999	999	999	999	999
PedAply	60	86	10	36	60	86	10	36	5	5	5	5	5	5	5	5	5	5
FloatMx	20	20	20	20	20	20	20	20	0	0	0	0	0	0	0	0	0	0
PedLeav	75	90	25	40	75	90	25	40	0	0	0	0	0	0	0	0	0	0
PedCall	55	80	5	30	55	80	5	30	0	0	0	0	0	0	0	0	0	0
SpltRem	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0



Easy <> P	1	2	3	4	5	6	7	8
PrimFrc	65	0	20	45	65	0	20	45
SecdFrc	65	0	20	45	65	0	20	45
Veh Yld	0	10	0	0	0	10	0	0
VehAply	56	91	11	36	56	91	11	36
Ped Yld	0	10	0	0	0	10	0	0
PedAply	65	91	20	36	65	91	20	36
FloatMx	15	30	15	20	15	30	15	20
PedLeav	65	90	20	35	65	90	20	35
PedCall	60	85	15	30	60	85	15	30
SpltRem	0	7	0	0	0	7	0	0





Spl- 1<>P	1	2	3	4	5	6	7	8
Time	25	25	25	25	25	25	25	25
Coor-P	.	X	.	.	.	.	.	.
Mode	NON	MAX	NON	NON	NON	MAX	NON	NON

All that is required to allocate cycle time using NTCIP FIXED and FLOAT are the *Split Times* (in seconds) for each phase. The controller automatically calculates the internal force-off and yield points (called Easy Calcs) given the split times and sequence of the pattern. However, for most users, the *Easy Calcs* (force-off and yield points calculated under FIXED and FLOAT) are “hidden from view” and all the user is concerned about is ensuring that the split times provided pass the coord diagnostic. The *Split Table* above assigns phase 2 as the *Coordinated Phase* with 25” S*plit Times* allocated to each phase.

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The pattern example to the right represents a 100" cycle with the offset referenced to *Begin-of-Green* (BegGRN) coord Ø2. All splits are 25" as shown in the *Split Table#* above and the clearance times for each phase are 5". The zero point of the cycle (Loc = 0) coincides with the beginning of the coordinated phase (in this case, phase 2). The green interval for Ø2 (and Ø6) is starts at Loc=0 and is ended at Loc=20 to provide a 25" *Split Time* once the 5 second clearance occurs. Each phase in the sequence is forced off 25" after the force-off for the previous phase starting at the coord phase and proceeding across the barriers.

Easy	P..1	...2	...3	...4	...5	...6	...7	..8>
PrimFrc	95	20	45	70	95	20	45	70
SecdFrc	95	20	45	70	95	20	45	70
Veh Yld	20	30	20	20	20	30	20	20
VehAply	86	11	36	61	86	11	36	61
Ped Yld	20	30	20	20	20	30	20	20
PedAply	95	11	45	61	95	11	45	61
FloatMx	20	20	20	20	20	20	20	20
PedLeav	95	10	45	60	95	10	45	60
PedCall	90	5	40	55	90	5	40	55
Split	25	25	25	25	25	25	25	25
SpltRem	0	69	0	0	0	69	0	0

The *Easy Calcs* status screen (**MM->2->8->2**) displays the internal calculations for this example under FIXED or FLOAT NTCIP modes. *Secondary Force-offs* only apply to the OTHER modes, so under FIXED and FLOAT, the *Primary* and *Secondary Force-offs* are the same. The *Yield* points opens the *Permissive Periods* to service vehicle and pedestrian calls for each phase. The *Apply* points close the *Permissive Periods*.

If the user changes pattern lengths or offsets, the software must get in step with the new pattern. For example, if the agency desires that the pattern length change from 90 sec to 120, the controller will need to smooth its way and add 40 seconds to the cycle length. If the agency desires to remain in the artery for until its force off (i.e. setting **Return Hold** to ON under **MM->2->5**) the new force off may keep the controller in a phase longer than the previous pattern depending on when the transition occurs.

Sequence changes will also affect the way the software will get in step with the new pattern. If phase rotations occur, then the controller software will need to get in step with the new rotation as well as recalculate cycle parameters based on the new rotation. It is recommended that the user set the parameter **FreeOnSeqChg** to **ON** so the controller will change the sequence at a barrier as well as recalculate cycle parameters based on the new cycle length and phase rotation.

Below is a summary of the Easy Calcs parameters.

Primary Force-Off

The Primary Force-Off is the point in the local cycle that a force-off is applied to a phase causing that phase to terminate and begin timing yellow clearance. A Primary Force-off will remain applied until the phase terminates.

Easy <>	P..1	...2	...3	...4	...5	...6	...7	...8
PrimFrc	65	0	20	45	65	0	20	45
SecdFrc	65	0	20	45	65	0	20	45
Veh Yld	0	10	0	0	0	10	0	0
VehAply	56	91	11	36	56	91	11	36
Ped Yld	0	10	0	0	0	10	0	0
PedAply	65	91	20	36	65	91	20	36
FloatMx	15	30	15	20	15	30	15	20
PedLeav	65	90	20	35	65	90	20	35
PedCall	60	85	15	30	60	85	15	30
SpltRem	0	0	0	0	0	0	0	0

Secondary Force-Off

The Secondary Force-Off is a momentary force-off applied prior to the Primary Force-off. Secondary Force-offs are useful when conditionally servicing phases or when a phase is to be forced off twice per cycle. The Secondary Force-off normally default to the value of Primary Force-off. **NOTE: This feature is not used in NTCIP Coordination.**

Vehicle Yield

The Vehicle Yield is that point in the cycle that a vehicle call on a phase will be serviced, i.e. that the phase's inhibit is removed. Note that the phase inhibit is automatically applied by the controller at a calculated time in advance of the primary force-off.

Vehicle Apply

The Vehicle Apply point defines the point in the cycle when the phase inhibit is applied. A phase may begin anytime between the Vehicle Yield point and the Vehicle Apply point. The Vehicle Apply point (VehAply) for each phase is calculated as:

Easy <> P..	1	2	3	4	5	6	7	8
PrimFrc	65	0	20	45	65	0	20	45
SecdFrc	65	0	20	45	65	0	20	45
Veh Yld	0	10	0	0	0	10	0	0
VehAply	56	91	11	36	56	91	11	36
Ped Yld	0	10	0	0	0	10	0	0
PedAply	65	91	20	36	65	91	20	36
FloatMx	15	30	15	20	15	30	15	20
PedLeav	65	90	20	35	65	90	20	35
PedCall	60	85	15	30	60	85	15	30
SpltRem	0	0	0	0	0	0	0	0

Vehicle Apply Point (VehAply) = Primary Force-off – ((Max Yellow + All Red) + Minimum Green)

The yield point must be earlier than the automatic application point for the phase to be serviced. If short-cycle offset correction is enabled, the yield point must be earlier still to allow for the effective reduction in split time that occurs when the local cycle timer corrects by running fast.

Pedestrian Yield

The Pedestrian Yield is that point in the cycle that a pedestrian call on a phase will be serviced, i.e. that the phases pedestrian inhibit is removed. The phase inhibit is automatically applied by the controller at a calculated time in advance of the primary force-off.

Ped Apply

The Ped Apply point defines the point in the cycle when the pedestrian phase inhibit is applied. A pedestrian phase may begin anytime between the Ped Yield point and the Ped Apply point. The PedApply point for each pedestrian phase is calculated as:

Ped Apply Point (PedAply) = Primary Force-off – ((Max Yellow + All Red) + Pedestrian Clear)

The same considerations described above for selecting vehicle yield points apply to determining pedestrian yield points except when the STOP-IN-WALK is enabled. Refer to the explanation of Stop-In-Walk.

FloatMx

Floating max time (*FloatMx*) is equal to the green portion of the split needed to terminate the phase prior to the force-off if the time allocated to the phase exceeds programmed split time. This is used as the max green time with floating force-offs.

PedLeav

The Pedestrian Leave Point is used when Rest-In-Walk is active. This is the point in time when the Pedestrian Clearance begins after the phase has been resting in walk.

PedCall

Ped Call displays the last time a call can be placed in the cycle so a pedestrian can be serviced in that cycle. Ped Call is only used when MinP is active, otherwise Ped Call = Ped Apply. The Ped Call point for each pedestrian phase is calculated as:

PedCall = Ped Apply - Max (red+yellow)

SplitRem

This is the remaining time in the split before the next cycle begins.

Lead Lag Calculation Examples – Choosing the coordinated Phase

This section will show the effect on the Easy Calcs when lead lag left sequencing occurs. In this section we will change Lead/ Lag phasing to show the effect on easy calcs

Consider STD8 Phase with the following programming:

Ring 1	1	2	3	4
Ring 2	5	6	7	8

Times	P.1	...2	...3	...4	...5	...6	...7	..8>
Min Grn	5	5	5	5	5	5	5	5
Gap,Ext	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Max 1	25	25	25	25	25	25	25	25
Max 2	50	50	50	50	50	50	50	50
Yel Clr	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Red Clr	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Walk	0	5	0	5	0	5	0	5
Ped Clr	0	10	0	10	0	10	0	10
Red Revt	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Add Init	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Max Init+	0	0	0	0	0	0	0	0

The coordination will run Pattern 1 (**ENDGRN**) as setup below

Pat#	Cycle	Offset	Split	Seqnc
1	100	0	1	1
2	0	0	2	1
3	100	0	3	1
4	0	0	0	1
5	0	0	0	1
6	0	0	0	1
7	0	0	0	1
8	0	0	0	1
9	0	0	0	1
10	0	0	0	1
11 +	0	0	0	1

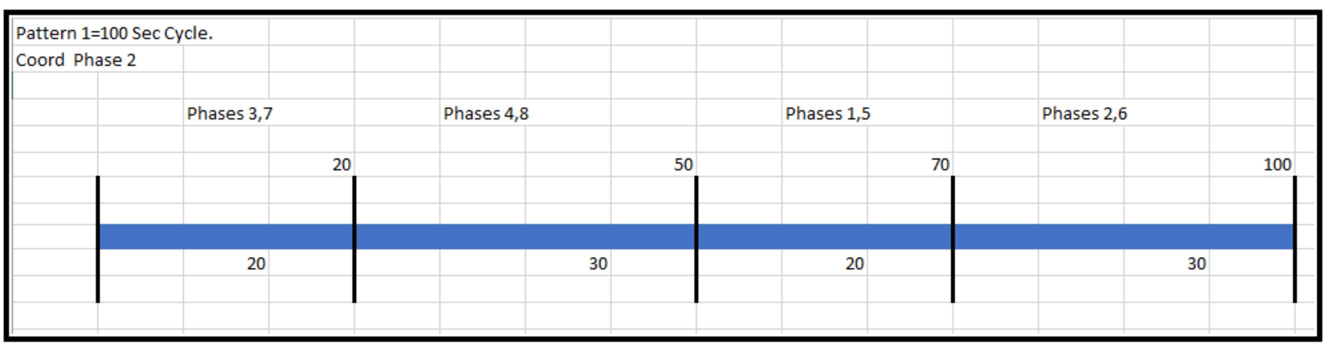
Spl- 1	P..1	...2	...3	...4	...5	...6	...7	..8>
Time	20	30	20	30	20	30	20	30
Coor-P	.	X	.	.	.	.	.	.
Mode	NON	MAX	NON	NON	NON	MAX	NON	NON

Pat#	Trans:	Short	Long	Dwell	No.Short.P>			
1		10	25	0	0	0	0	0
2		10	25	0	0	0	0	0
3		10	25	0	0	0	0	0
4		0	17	0	0	0	0	0
5		0	17	0	0	0	0	0
6		0	17	0	0	0	0	0
7		0	17	0	0	0	0	0
8		0	17	0	0	0	0	0
9		0	17	0	0	0	0	0
10		0	17	0	0	0	0	0
11	+	0	17	0	0	0	0	0

<Pat	EYld	Offst	RtHld	Flt	MinVP	%	MI
1	0	EndGr	X	.	..	.	.
2	0	EndGr	.	.	..	.	.
3	0	EndGr	X	.	..	.	.
4	0	BegGr	.	.	..	.	.
5	0	BegGr	.	.	..	.	.
6	0	BegGr	.	.	..	.	.
7	0	BegGr	.	.	..	.	.
8	0	BegGr	.	.	..	.	.
9	0	BegGr	.	.	..	.	.
10	0	BegGr	.	.	..	.	.
11 +	0	BegGr	.	.	..	.	.

The Easy Calcs created when running this pattern as shown below:

Easy	P..1	..2	..3	..4	..5	..6	..7	..8>
PrimFrc	70	0	20	50	70	0	20	50
SecdFrc	70	0	20	50	70	0	20	50
Veh Yld	0	10	0	0	0	10	0	0
VehAply	61	91	11	41	61	91	11	41
Ped Yld	0	10	0	0	0	10	0	0
PedAply	70	91	20	41	70	91	20	41
FloatMx	15	25	15	25	15	25	15	25
PedLeav	70	90	20	40	70	90	20	40
PedCall	65	85	15	35	65	85	15	35
Split	20	30	20	30	20	30	20	30
SpltRem	0	3	0	0	0	3	0	0



Choosing Phases 2 or 6 as the coord Phase would have no impact because both lefts are leading.

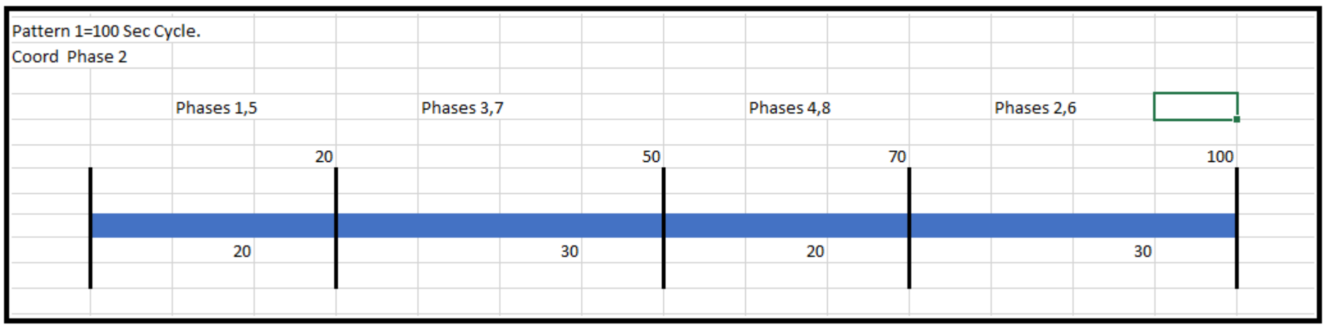
Note: NTCIP requires that only one phase is chosen as the coordinated phase. In this case we chose phase 2. Phase 6 which runs with phase 2 gets the benefit of coordination and is also known as the "**Pseudo-Coord**" phase.

Now change the phase sequence to Sequence # 4 to make Phases 1 and 5 Lagging Phases:

2	1	3	4
6	5	7	8

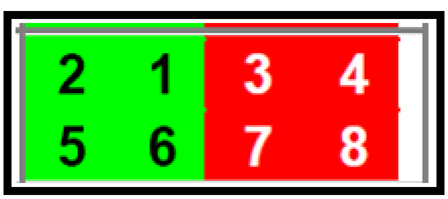
The Easy Calcs are shown below:

Easy	1	2	3	4	5	6	7	8
PrimFrc	20	0	40	70	20	0	40	70
SecdFrc	20	0	40	70	20	0	40	70
Veh Yld	0	30	20	20	21	30	20	20
VehAply	11	91	31	61	11	91	31	61
Ped Yld	0	30	20	20	21	30	20	20
PedAply	20	91	40	61	20	91	40	61
FloatMx	15	25	15	25	15	25	15	25
PedLeav	20	90	40	60	20	90	40	60
PedCall	15	85	35	55	15	85	35	55
Split	20	30	20	30	20	30	20	30
SpltRem	0	95	0	0	0	95	0	0



Choosing Phases 2 or 6 as the coord Phase would have no impact because both lefts are lagging.

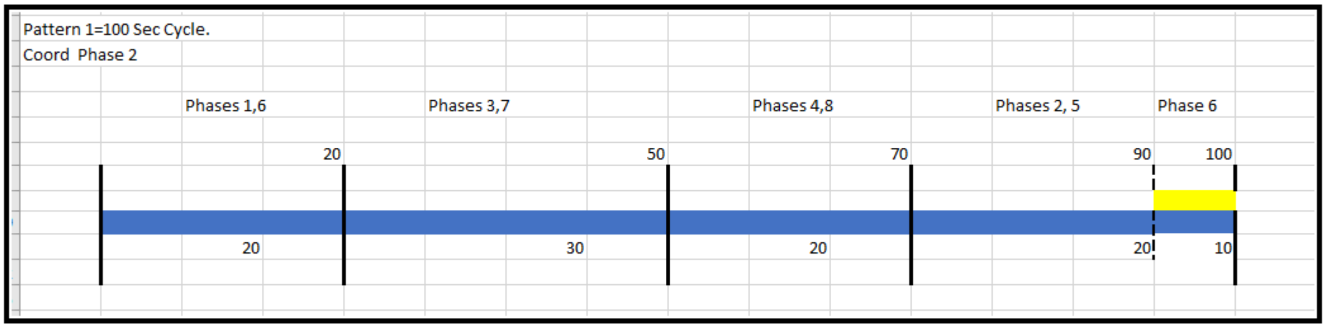
Now choose Phase 1 as a Lagging left and Phase 5 as a leading Left using sequence 3.



The Easy calcs are shown below

Easy	1	2	3	4	5	6	7	8
PrimFrc	20	0	40	70	90	20	40	70
SecdFrc	20	0	40	70	90	20	40	70
Veh Yld	0	30	20	20	30	21	20	20
VehAply	11	91	31	61	81	11	31	61
Ped Yld	0	30	20	20	30	21	20	20
PedAply	20	91	40	61	90	11	40	61
FloatMx	15	25	15	25	15	25	15	25
PedLeav	20	90	40	60	90	10	40	60
PedCall	15	85	35	55	85	5	35	55
Split	20	30	20	30	20	30	20	30
SpltRem	0	56	0	0	0	76	0	0

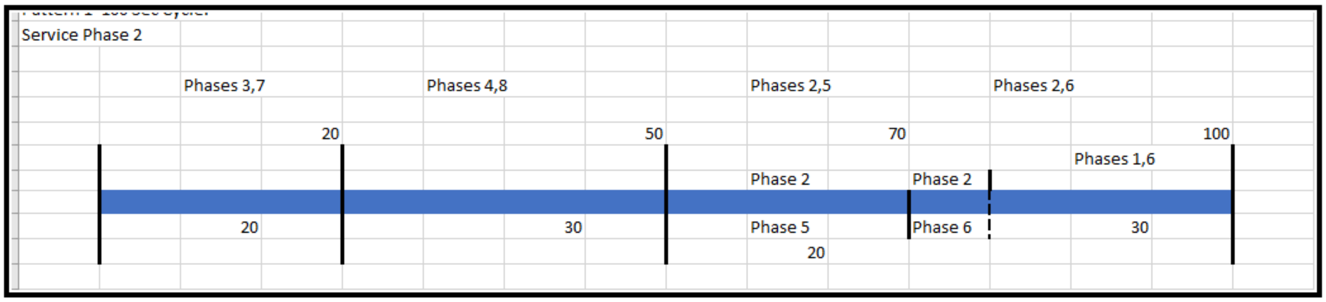
Phase 5 leaves before the "ENDGRN" for Phase 2. This in effect, gives Phase 6 an extra 10 seconds of green, which may be unintended. This could lead to inefficiency. In addition, if other phases in the corridor have sequences, unintended queues on those intersections may occur. Placing the coord reference point between phases (in this case at Phase 2) and not at a barrier is allowed, but the agency should intend to do so.



A recommended and simple way to resolve this issue is to change the coordinated phase to the phase that controls coordination AT THE BARRIER, in this case Phase 6.

Below is the Easy Calcs when phase 6 is the coord Phase.

Easy	P..1	...2	...3	...4	...5	...6	...7	..8>
PrimFrc	0	80	20	50	70	0	20	50
SecdFrc	0	80	20	50	70	0	20	50
Veh Yld	10	0	0	0	0	10	0	0
VehAply	91	71	11	41	61	91	11	41
Ped Yld	10	0	0	0	0	10	0	0
PedAply	0	71	20	41	70	91	20	41
FloatMx	15	25	15	25	15	25	15	25
PedLeav	0	70	20	40	70	90	20	40
PedCall	95	65	15	35	65	85	15	35
Split	20	30	20	30	20	30	20	30
SpltRem	0	91	0	0	0	11	0	0



Similar results occur if the Coord Reference Point is changed to **BEGGRN**.

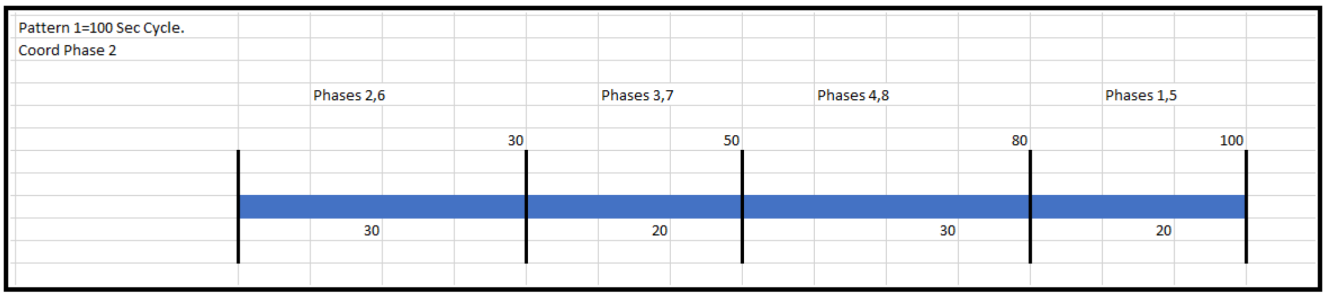
Pat#	Trans:	Short	Long	Dwell	No.Short.P>			
1		10	25	0	0	0	0	0
2		10	25	0	0	0	0	0
3		10	25	0	0	0	0	0
4		0	17	0	0	0	0	0
5		0	17	0	0	0	0	0
6		0	17	0	0	0	0	0
7		0	17	0	0	0	0	0
8		0	17	0	0	0	0	0
9		0	17	0	0	0	0	0
10		0	17	0	0	0	0	0
11	+	0	17	0	0	0	0	0

<Pat	EYld	Offst	RtHld	Flt	MinVP	%	MI
1	0	BegGr	.	.	..	.	.
2	0	BegGr	.	.	..	.	.
3	0	BegGr	.	.	..	.	.
4	0	BegGr	.	.	..	.	.
5	0	BegGr	.	.	..	.	.
6	0	BegGr	.	.	..	.	.
7	0	BegGr	.	.	..	.	.
8	0	BegGr	.	.	..	.	.
9	0	BegGr	.	.	..	.	.
10	0	BegGr	.	.	..	.	.
11 +	0	BegGr	.	.	..	.	.

For Sequence 1, The Easy Calcs are shown below.

Easy	P..1	...2	...3	...4	...5	...6	...7	..8>
PrimFrc	95	25	45	75	95	25	45	75
SecdFrc	95	25	45	75	95	25	45	75
Veh Yld	25	35	25	25	25	35	25	25
VehAply	86	16	36	66	86	16	36	66
Ped Yld	25	35	25	25	25	35	25	25
PedAply	95	16	45	66	95	16	45	66
FloatMx	15	25	15	25	15	25	15	25
PedLeav	95	15	45	65	95	15	45	65
PedCall	90	10	40	60	90	10	40	60
Split	20	30	20	30	20	30	20	30
SpltRem	0	0	0	0	0	0	0	0

Ring 1	1	2	3	4
Ring 2	5	6	7	8



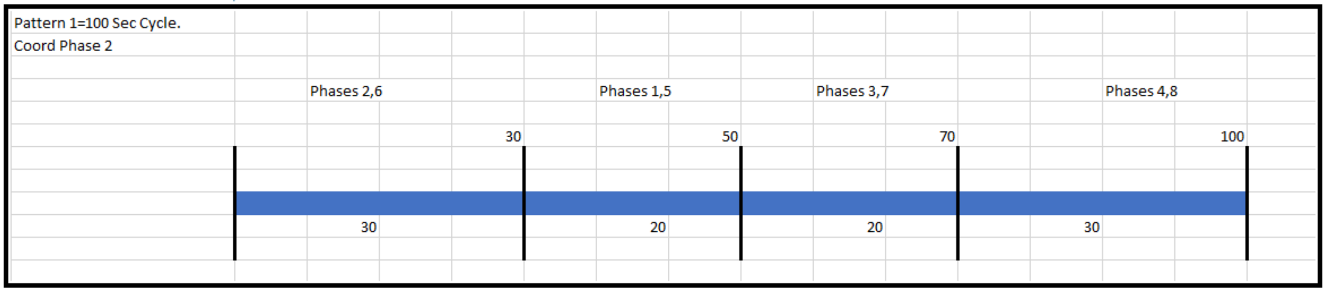
Choosing Phases 2 or 6 as the coord Phase would have no impact because both lefts are leading.

Now change the phase sequence to Sequence # 4 to make Phases 1 and 5 Lagging Phases:

2	1	3	4
6	5	7	8

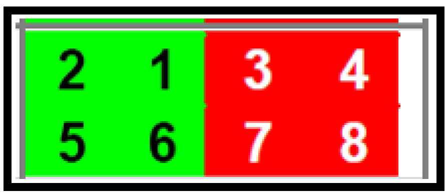
The Easy Calcs are shown below:

Easy	P..1	...2	...3	...4	...5	...6	...7	..8>
PrimFrc	45	25	65	95	45	25	65	95
SecdFrc	45	25	65	95	45	25	65	95
Veh Yld	25	55	45	45	46	55	45	45
VehAply	36	16	56	86	36	16	56	86
Ped Yld	25	55	45	45	46	55	45	45
PedAply	45	16	65	86	45	16	65	86
FloatMx	15	25	15	25	15	25	15	25
PedLeav	45	15	65	85	45	15	65	85
PedCall	40	10	60	80	40	10	60	80
Split	20	30	20	30	20	30	20	30
SpltRem	0	61	0	0	0	61	0	0



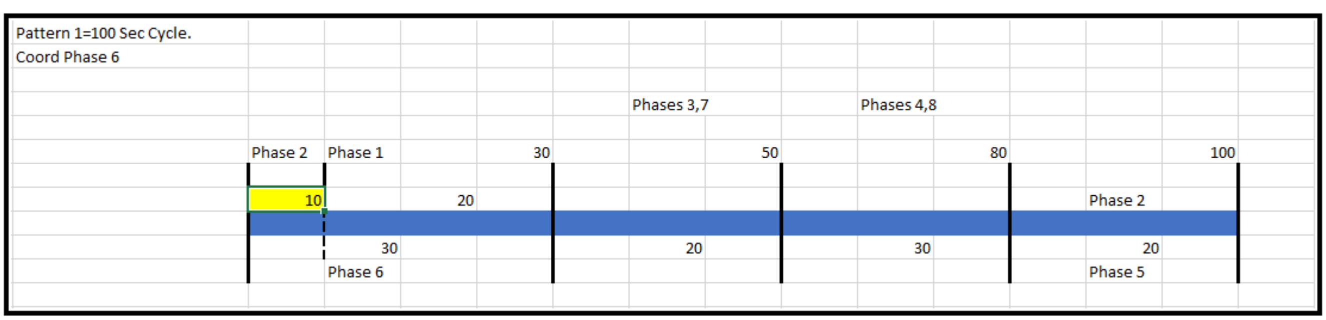
Choosing Phases 2 or 6 as the coord Phase would have no impact because both lefts are lagging.

Now choose Phase 1 as a Lagging left and Phase 5 as a leading Left using sequence 3 with Phase 6 as the Coordinated Phase



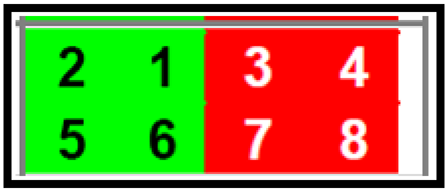
The Easy calcs are shown below

Easy	P..1	...2	...3	...4	...5	...6	...7	..8>
PrimFrc	25	5	45	75	95	25	45	75
SecdFrc	25	5	45	75	95	25	45	75
Veh Yld	35	25	25	25	25	35	25	25
VehAply	16	96	36	66	86	16	36	66
Ped Yld	35	25	25	25	25	35	25	25
PedAply	25	96	45	66	95	16	45	66
FloatMx	15	25	15	25	15	25	15	25
PedLeav	25	95	45	65	95	15	45	65
PedCall	20	90	40	60	90	10	40	60
Split	20	30	20	30	20	30	20	30
SpltRem	0	90	0	0	0	10	0	0



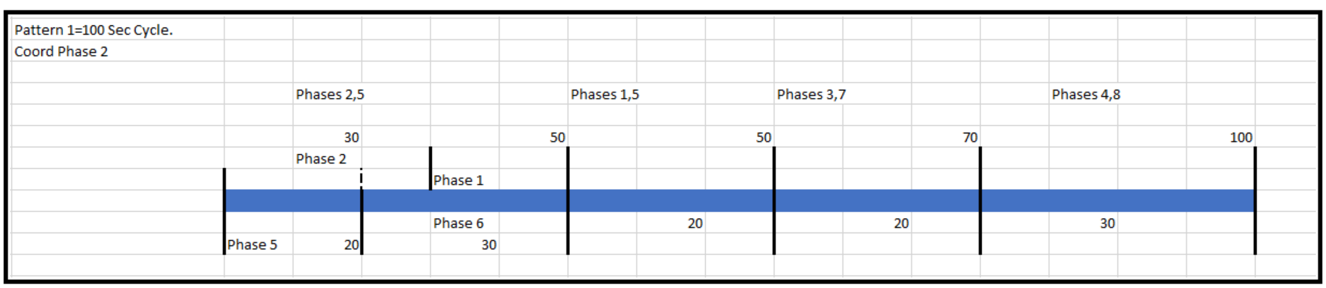
Note that Phase 2 (the Pseudo-Coordinated Phase) bridges between the last cycle and the new cycle. In fact, once the next cycle begins phase 2 only has 5 seconds of green begore it clears to run Phase 1. This could have un intended results.

Instead if we choose 0Phase 2 as the Coordinated Phase under the same Sequence 3 Lead/Lag Left scenario.



The Easy calcs are shown below

Easy	P..1	...2	...3	...4	...5	...6	...7	..8>
PrimFrc	45	25	65	95	15	45	65	95
SecdFrc	45	25	65	95	15	45	65	95
Veh Yld	25	55	45	45	55	46	45	45
VehAply	36	16	56	86	6	36	56	86
Ped Yld	25	55	45	45	55	46	45	45
PedAply	45	16	65	86	15	36	65	86
FloatMx	15	25	15	25	15	25	15	25
PedLeav	45	15	65	85	15	35	65	85
PedCall	40	10	60	80	10	30	60	80
Split	20	30	20	30	20	30	20	30
SpltRem	0	10	0	0	0	30	0	0



Although the Lead/Lag lefts occur, it has no effect on coordination or phase splits.

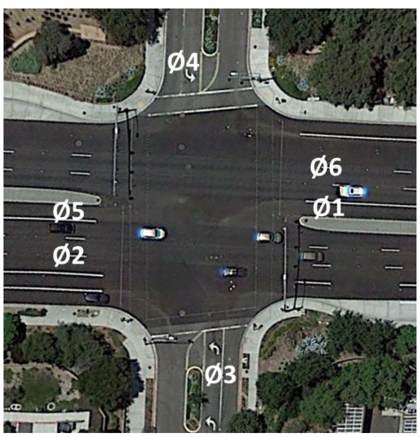
To repeat, a recommended and simple way to resolve this issue is to change the coordinated phase to the phase that controls coordination AT THE BARRIER, in this case Phase 2.

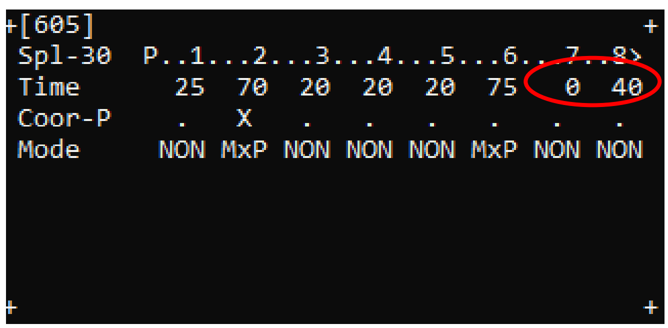
SynchroGreen Adaptive Considerations

The fundamental difference between SynchroGreen and traditional TBC is that SynchroGreen transmits new cycle, split and offset data each cycle. At the local zero, the controller uses that data to recalculate new Easy Calcs, which control how the signal times during the cycle.

The preferred phasing is Standard 8 Phase operations (STD-8) or Quad Sequential (QSeq) operations. In the event that Standard 8 Phase operation cannot be enabled due to non-standard phasing, User Programmable Mode (USER) should be used. If USER mode is selected, the agency should verify that all ring sequences used for adaptive operations all form complete ring and barrier structures. Incomplete ring and barrier structure may produce errors in SynchroGreen. Incomplete ring and barrier structures will commonly result in coordination errors. It is a good rule of thumb to include all eight phases, (e.g., 1, 2, 3, 4, 5, 6, 7, 8) in the ring and barrier structure even if a phase is not enabled.

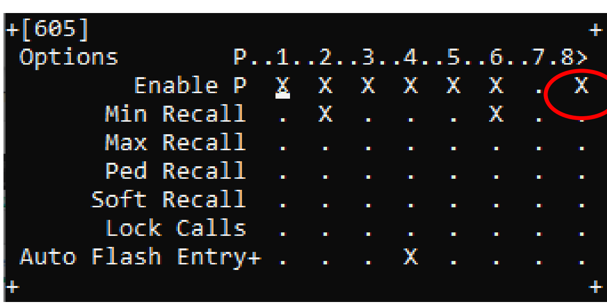
A difference between ring and phasing structures between controllers operating standard coordination and adaptive coordination is that controllers operating adaptively must have **an enabled phase in each ring in each barrier group with phase times.** As an example, consider the following intersection. Phases 1,2,3,4,5,6 are active at this intersection. To pass coordination checks, the user must define time in for enabled phases 1-6 as well as time for inactive phases 7 or 8, as shown below. This applies when programming standard or adaptive coordination plans. However, when programming adaptive plans, the user must enable phase 8 as a "dummy" or "ghost" phase in **MM->1->1->2** and define phase times in **MM->1->1->1**. A standard practice is to define a minimum green of 1" in the dummy phase 8.





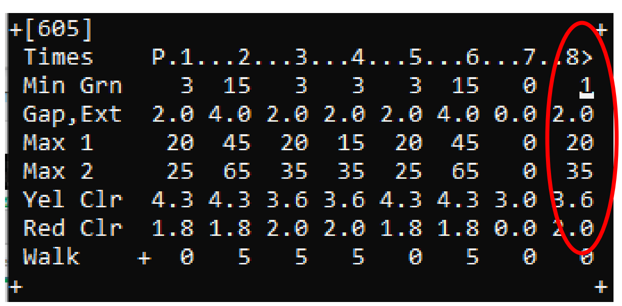
+[605]

Spl-30	P..1	...2	...3	...4	...5	...6	...7	..8>
Time	25	70	20	20	20	75	0	40
Coor-P	.	X	.	.	.	.	.	.
Mode	NON	MxP	NON	NON	NON	MxP	NON	NON



+[605]

Options	P..1	..2	..3	..4	..5	..6	..7	.8>
Enable P	X	X	X	X	X	X	.	X
Min Recall	.	X	.	.	.	X	.	.
Max Recall	.	.	.	.	.	.	.	.
Ped Recall	.	.	.	.	.	.	.	.
Soft Recall	.	.	.	.	.	.	.	.
Lock Calls	.	.	.	.	.	.	.	.
Auto Flash Entry+	.	.	.	X	.	.	.	.

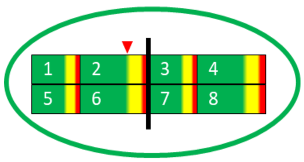


+[605]

Times	P.1	...2	...3	...4	...5	...6	...7	..8>
Min Grn	3	15	3	3	3	15	0	1
Gap,Ext	2.0	4.0	2.0	2.0	2.0	4.0	0.0	2.0
Max 1	20	45	20	15	20	45	0	20
Max 2	25	65	35	35	25	65	0	35
Yel Clr	4.3	4.3	3.6	3.6	4.3	4.3	3.0	3.6
Red Clr	1.8	1.8	2.0	2.0	1.8	1.8	0.0	2.0
Walk +	0	5	5	5	0	5	0	0

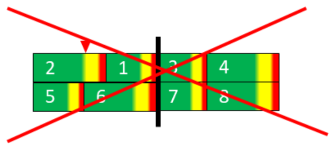
The above only applies when operating a controller in STD-8 or USER phase mode. If a controller is operated in QSeq phase mode, the dummy phase programming previously shown is not required

Another difference between defining standard coordination patterns and adaptive coordination patterns is that the for a SynchroGreen pattern must be "touching a barrier." In other words, when the *Offset Reference Point* is at the beginning of green, it is important that the coordinated phase be the leading phase. Alternatively, when the *Offset Reference Point* is at the end of green (beginning of yellow), the coordinated phase should be the lagging phase. This is important so that Synchro-Green can provide consistent and predictable coordination. The user should check the phase sequence (**MM->1->2->4**), phase concurrency tables (**MM->1->1->4**) and the reference points (**MM->2->5**) to verify that adaptive patterns are properly configured. This is shown below in the following examples:



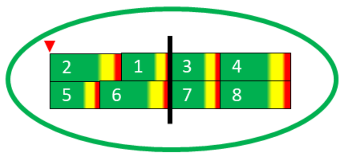
Seq = 1
Coord Ø = 2
Ref = EndGrn

Correct. Ref Point is End Green which touches a barrier.



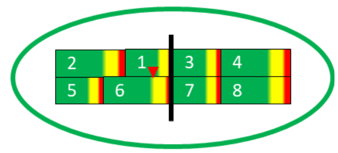
Seq = 3
Coord Ø = 2
Ref = EndGrn

Wrong. Ref Point is End Green, but controller is not crossing a barrier at local zero.



Seq = 3
Coord Ø = 2
Ref = BegGrn

Correct. Ref Point is Beg Green which touches a barrier.



Seq = 3
Coord Ø = 6
Ref = EndGrn

Correct. Ref Point is End Green in Ring 2 which touches a barrier. The reference point may be in either ring.

Summary

Lead Lag Considerations have an impact on signal operations and the engineer must evaluate the implications of the lead Lag phasing. Once engineered the agency should **ALWAYS** test the operations prior to installing in the field.