

Contents

3 Signal Operations and Operational Approval..... 2

3.3 Normal Phase Rotation 2

3.3.12 Right-Turn Flashing Yellow Arrow..... 2

3.4 Emergency Preemption 5

3.4.1 Operation of Overlaps and Flashing Yellow Arrows 5

5 Signal Plan 8

5.2 Vehicle Signal Head Layout 8

5.2.1 Head Types 8

5.14 Wiring 12

5.14.6 Wiring Signal Heads (From Head to Terminal Cabinet)..... 12

5.15 Background/Reference Information 13

5.15.4 Right-Turn Flashing Yellow Arrow (Type 3RCF Signal Head)..... 13

20 Cabinet Print..... 19

20.7 Cabinet Print (Page 3 – Output File)..... 19

20.7.3 Conflict Monitor Diode Card 19

20.7.5 Additional Information for the Output File 23

20.7.7 Output File & Conflict Monitor Configuration For Right-Turn Flashing Yellow Arrow (Type 3RCF Signal Head)..... 23

21 Traffic Signal Policy and Guidelines..... 27

This content in this document addresses Protected/permitted right turn phasing using a flashing yellow arrow type 3RCF signal head. It is a draft and subject to change (e.g., further discussion of info presented in “Traffic Signal Policy and Guidelines” on the last two pages and TSSU testing of the cabinet output configuration is still needed and will occur in 2023). However, this content may be used for projects on a case-by-case basis with concurrence from the State Traffic Signal Engineer and the State Traffic Operations Engineer. **FEEDBACK IS APPRECIATED** as we move forward with incorporating this new info into manuals.

The following sections propose *new* inserts in the 2023 Traffic Signal Design Manual, unless noted otherwise **in blue** at the beginning of the section (where edits to the existing sections are shown using **track changes in red**).

3 Signal Operations and Operational Approval

3.3 Normal Phase Rotation

3.3.12 Right-Turn Flashing Yellow Arrow

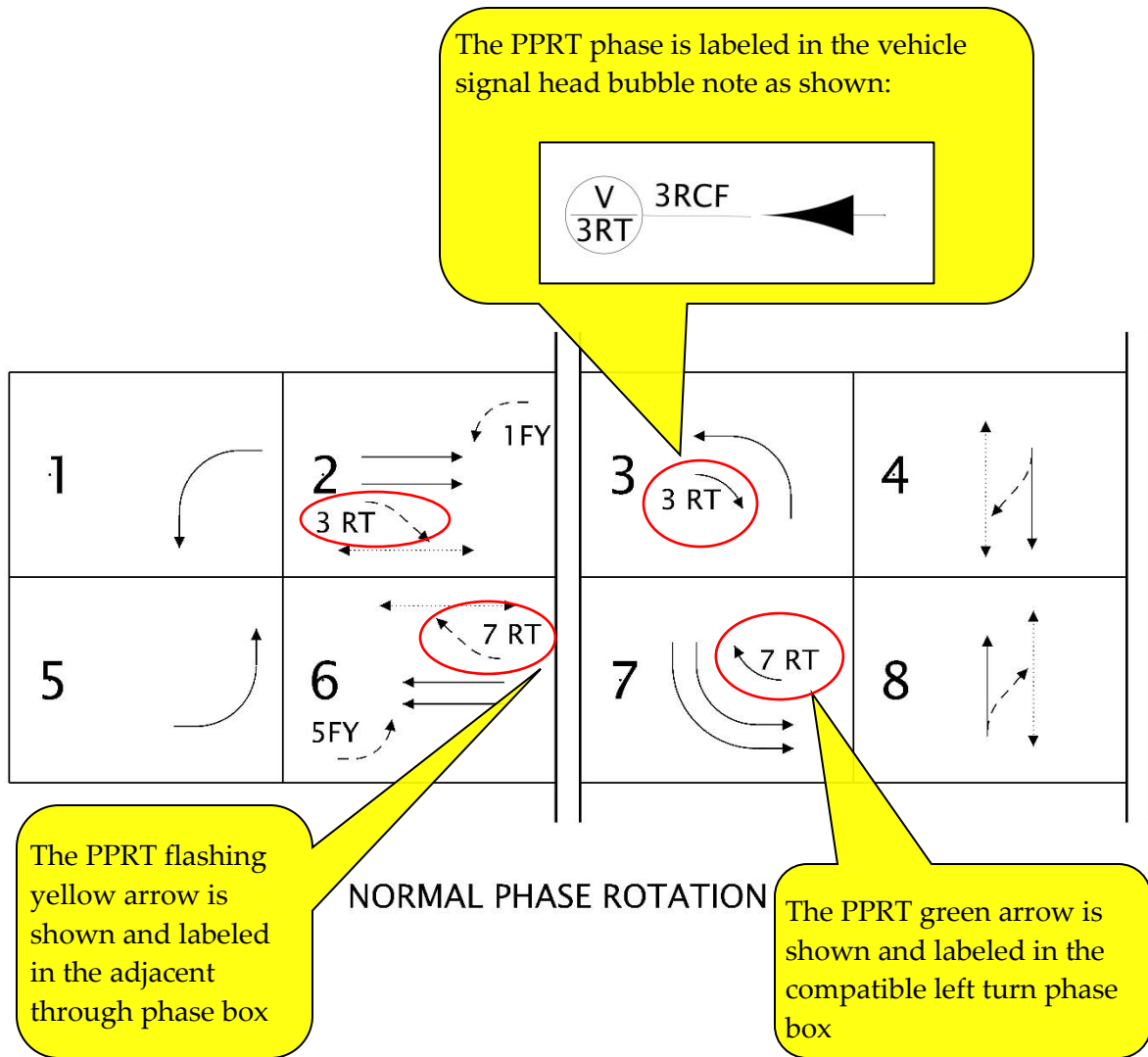
The right-turn flashing yellow arrow (type 3RCF signal head) is the current standard for protected/permissive right turn (PPRT) phasing. The permissive phase is shown in the adjacent through phase box and the protected phase is shown in the compatible left-turn phase box. Both the permissive and protected phases are labeled with the protected left-turn phase number followed by “RT” (e.g., 1RT, 3RT, 5, RT, or 7RT). This label also serves as the “phase” for the PPRT movement on the plan sheet bubble notes to provide a clear way label the terminal blocks and control cables associated with the type 3RCF signal head. See Figure 3-1. **If the compatible protected left turn is due to split phasing (e.g. there is no actual protected left turn phase 1, 3, 5, or 7), the permissive and protected phases are instead labeled with the compatible split phase number followed by “RT” (e.g., 2RT, 4RT, 6RT, or 8RT). See Figure 3-2.**

Flashing yellow arrow with NOT-PED refers to timing that restricts the permissive right-turn (flashing yellow arrow) from being served if the pedestrian phase crossing the lane used by the permissive right-turn is active (active ped phases options include: 1.) the WALK indication only, 2.) the WALK indication and a portion of the FLASHING DON'T WALK indication, or 3.) the WALK indication and the entire FLASHING DON'T WALK indication). For example, in Figure 3-1, if pedestrian phase 2 is displaying the WALK indication (or FLASHING DON'T WALK indication), the phase 3RT right-turn indication will display a solid RED arrow.

The flashing yellow arrow NOT-PED timing feature is NOT shown in the ring and barrier diagram as it is not a conflict that results in inappropriate signal operations if the flashing yellow arrow and pedestrian phase are served together (MUTCD section 4D.21 paragraph 03 allows a permissive right turn phase and the pedestrian phase crossing the lane used by the permissive right-turn to be active at the same time).

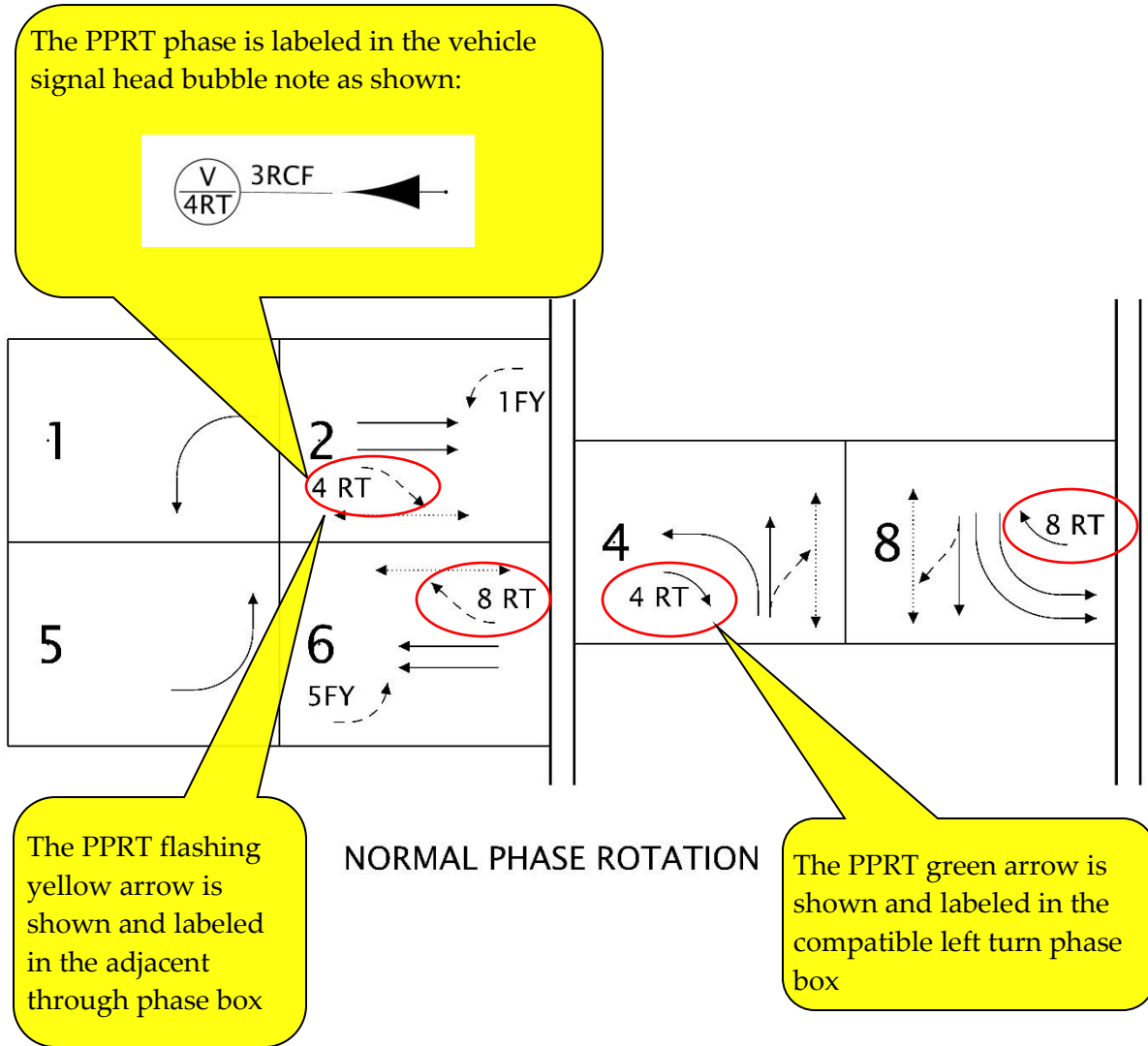
Traffic Signal Design Manual – Proposed update type 3RCF signal head for PPRT

Figure 3-1 | Ring and Barrier Diagrams: Right-Turn Flashing Yellow Arrow Labeling (Typical Example)



Traffic Signal Design Manual – Proposed update type 3RCF signal head for PPRT

Figure 3-2 | Ring and Barrier Diagrams: Right-Turn Flashing Yellow Arrow Labeling (Split Phase Example)

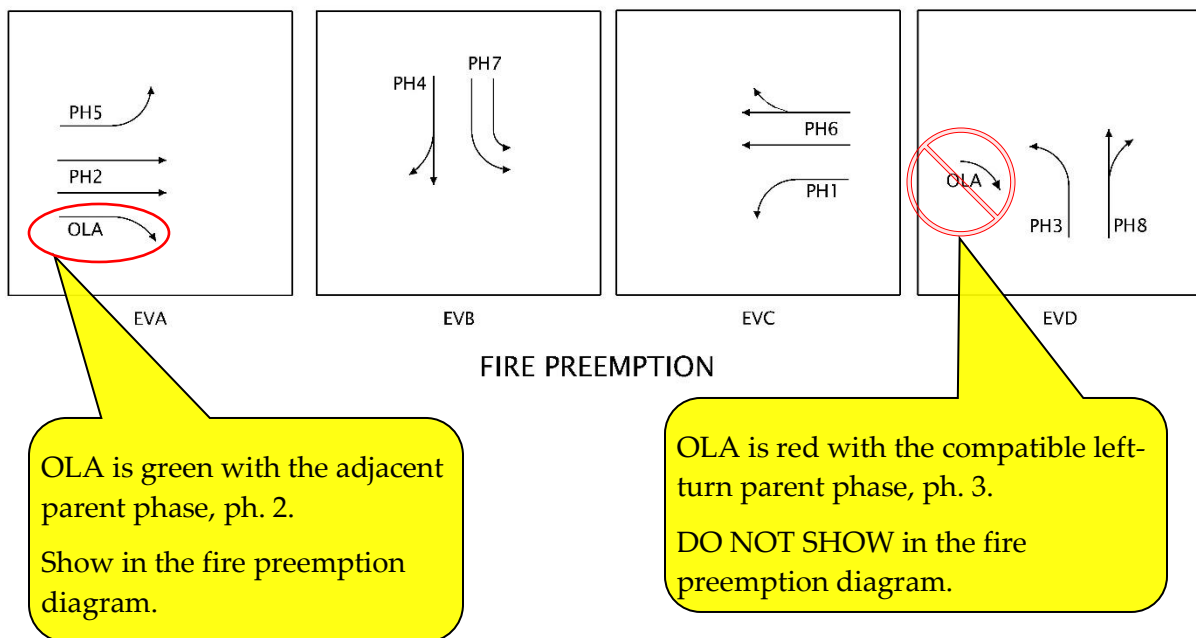


3.4 Emergency Preemption

3.4.1 Operation of Overlaps and Flashing Yellow Arrows

Overlap phases typically have two or more parent phases. During emergency preemption operation, the overlap phase should only be green when the parent phase is on the same approach. The overlap phase should be red when the parent phase on the different approach is preempted. This operation should be shown in the fire preemption diagram. See Figure 3-3.

Figure 3-3 | Fire Preemption Operation with Overlaps



Traffic-Roadway Section

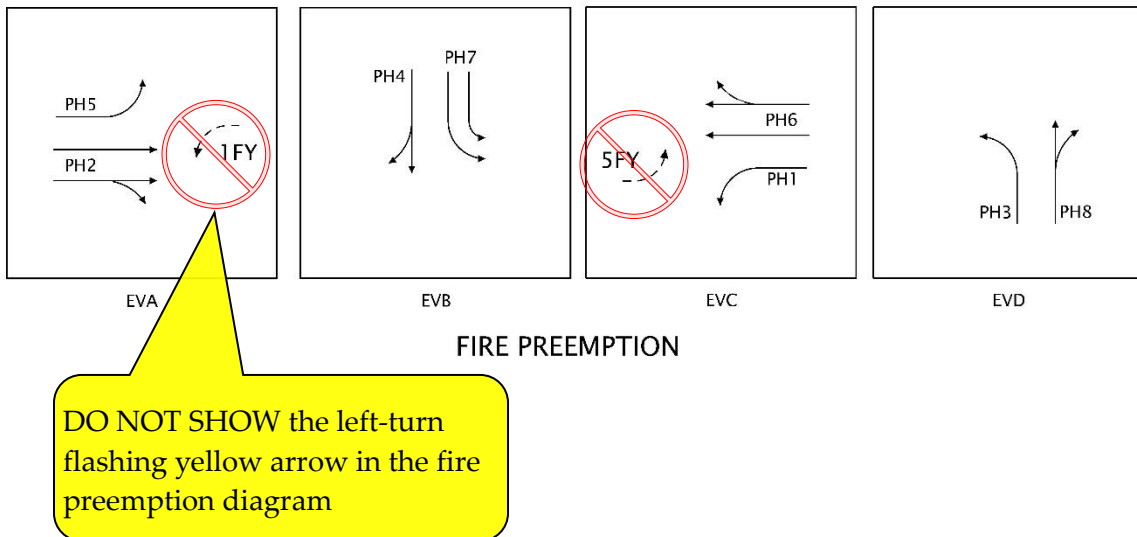
Traffic Signal Design Manual – Proposed update type 3RCF signal head for PPRT

Left-turn flashing yellow arrow indications normally operate when the opposing through phase is green. During emergency preemption, the left-turn flashing yellow indication should operate as follows:

- If it is ON when a preemption input for the opposing through phase is received, it should remain ON.
- If it is OFF when the preemption input is received for the opposing through phase, it should remain OFF.

This operation eliminates yellow trap from occurring during emergency preemption. The left-turn flashing yellow arrow will not always be on during preemption and therefore it is not shown in the fire preemption diagram. See Figure 3-4.

Figure 3-4 | Fire Preemption Operation with Left-Turn Flashing Yellow Arrow



Traffic-Roadway Section

Traffic Signal Design Manual – Proposed update type 3RCF signal head for PPRT

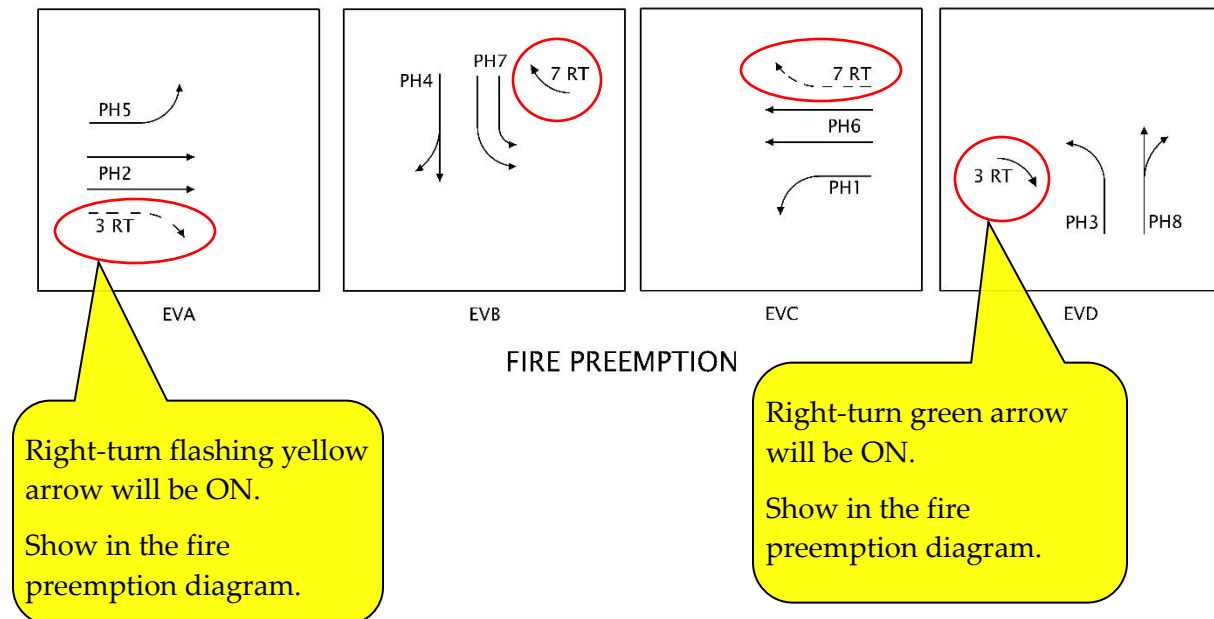
Right-turn flashing yellow arrow indications will operate in slightly different manner than left-turn flashing yellow arrow indications during emergency preemption due to the required output configuration of the type 3RCF signal head. The right-turn flashing yellow arrow will be on when the adjacent through phase is preempted and the right-turn green arrow will be on when the compatible left-turn phase is preempted. This operation unfortunately allows a right-turn green arrow that may conflict with an emergency vehicle that needs to bypass standing queues by traveling in the oncoming receiving lane of the right-turn. While not ideal, it is a low risk for the following reasons:

- Emergency vehicle drivers are trained on how to properly navigate intersections with conflicting signal indications
- Emergency preemption is never guaranteed (e.g., emergency preemption cannot override and terminate a flashing don't walk pedestrian phase)
- Drivers are required to yield right-of-way to emergency vehicles by law
- This preemption operation is identical for existing type 5 signal heads which have been used for many years without any reported incidents or complaints

This operation should be shown in the fire preemption diagram. See

Figure 3-5.

Figure 3-5 | Fire Preemption Operation With Right-Turn Flashing Yellow Arrow



5 Signal Plan

5.2 Vehicle Signal Head Layout

5.2.1 Head Types



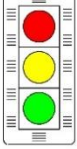
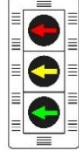
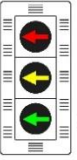
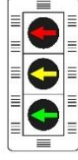
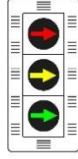
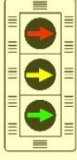
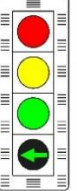
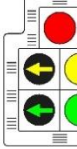
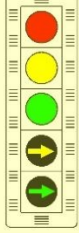
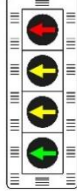
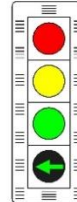
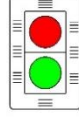
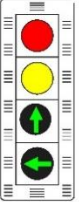
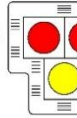
Revise the following existing text as shown below in track changes:

If the need arises to use a signal head type or layout that that is not covered by this manual (such as bike, U-turn, ~~flashing yellow right turn arrow~~, etc.), contact the State Traffic Signal Engineer to discuss and resolve the unique situation. See Section 2.2 for more information on non-standard and experimental design.

Traffic-Roadway Section

Traffic Signal Design Manual – Proposed update type 3RCF signal head for PPRT

Replace existing Figure 5-22 (Signal head types) with the following figure highlighting the changes with yellow boxes outlined in blue:

<p>TYPE 1R Used for flashing beacons</p>  <p>FR</p>	<p>TYPE 1Y Used for flashing beacons</p>  <p>FY</p>	<p>TYPE 2 Standard signal head (Allows permissive left & right turns & through moves)</p>  <p>R Y G</p>	<p>TYPE 3L Standard signal head for protected left turns</p>  <p>RA YA GA</p>
<p>TYPE 3LBF "Bottom Flashing Yellow Arrow" (Bi-modal) Alternative signal head for protected/permitted left turn</p>  <p>RA YA GA</p>	<p>TYPE 3LCF "Center Flashing Yellow Arrow" Standard signal head for protected/permitted left turn</p>  <p>RA YA/FYA GA</p>	<p>TYPE 3R Standard signal head for protected right turns (e.g. overlap phase)</p>  <p>RA YA GA</p>	<p>TYPE 3RCF "Center Flashing Yellow Arrow" Standard signal head for protected/permitted right turn</p>  <p>RA YA/FYA GA</p>
<p>TYPE 4 Used for split phasing (protected left turn & thru move)</p>  <p>R Y G GA</p>	<p>TYPE 4L "Doghouse" old standard used for protected/permitted left turn NOT for new installations</p>  <p>R YA Y G GA</p>	<p>TYPE 5 Old standard used for protected/permitted right turn NOT for new installations</p>  <p>R Y G YA GA</p>	<p>TYPE 6L "Flashing Yellow Arrow" Old Standard used for protected/permitted left turn NOT for new installations</p>  <p>RA YA FYA GA</p>
<p>TYPE 7 ONLY used for Railroad preemption when the track clearance phase has a permissive left turn</p>  <p>R Y G GA</p>	<p>TYPE 8 ONLY used for ramp meters</p>  <p>R G</p>	<p>TYPE 9 ONLY used for split phasing with a specific lane use configuration</p>  <p>R Y GA GA</p>	<p>TYPE 10 ONLY used HAWK signals</p>  <p>R + FR R + FR Y + FY</p>
<p>Color Indication Abbreviations. All Indications are 12" diameter.</p> <p>R = Red Circular Ball RA = Red Arrow FYA = Flashing Yellow Arrow Y = Yellow Circular Ball YA = Yellow Arrow FR = Flashing Red Circular Ball G = Green Circular Ball GA = Green Arrow FY = Flashing Yellow Circular Ball</p>			

Traffic-Roadway Section

Traffic Signal Design Manual – Proposed update type 3RCF signal head for PPRT

Update existing table 5-3 (Standard Signal heads for right-turn phases) for overlap phasing and PPRT 2-phase operation as shown below in track changes:

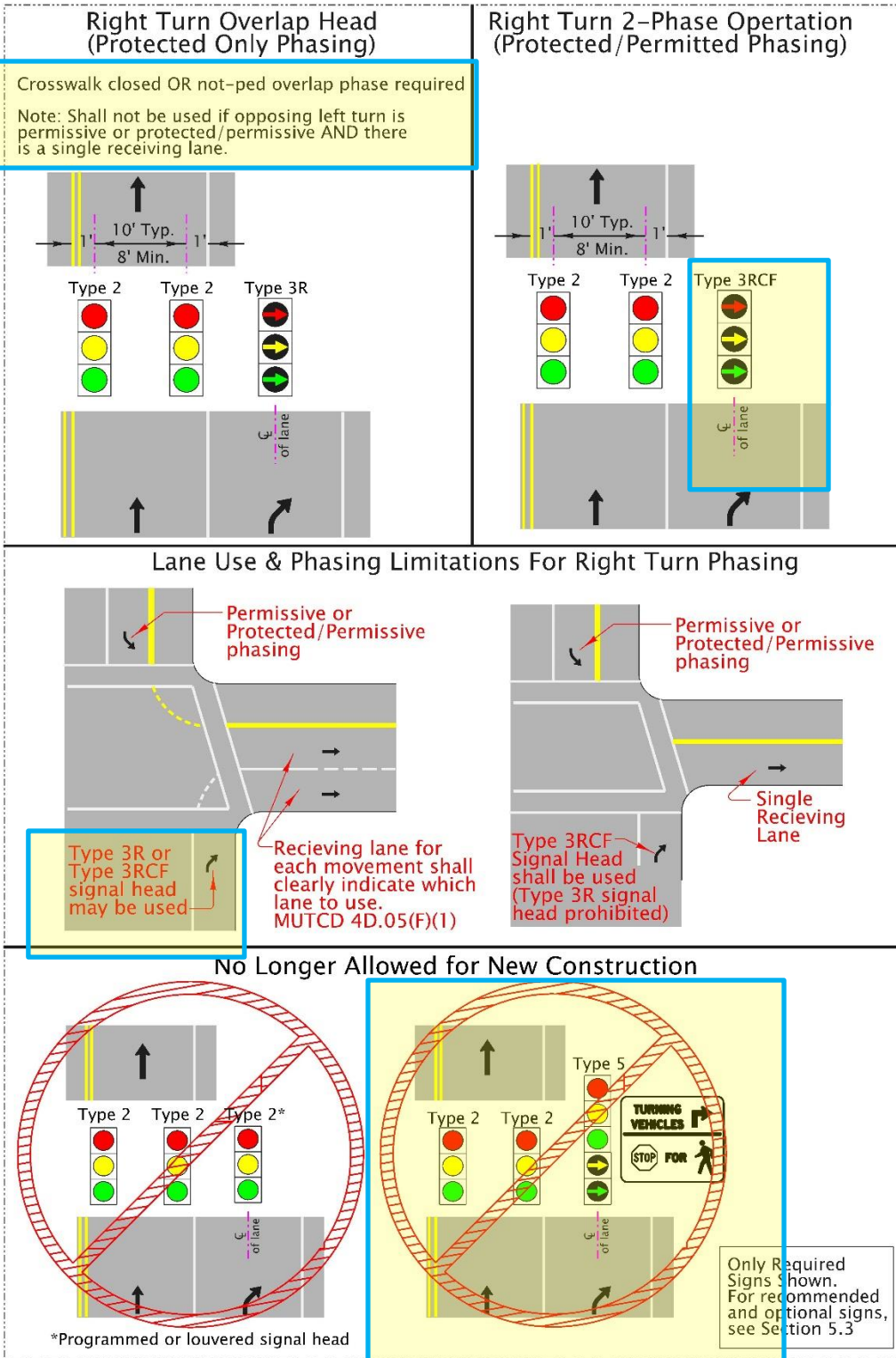
Standard Signal Heads for Right-Turn Phases	
Type of Operation	Number and placement of signal heads
Overlap phasing (operating as protected only)	<p>One type 3R signal head, placed in the center of the projected lane lines*. This is the standard when using an ATC controller (conflicting crosswalk phase must either be officially closed as described in section 5.1.2 or use the not-ped overlap phase as described in section 3.3.5. "not-ped" software feature).</p> <p>Note: The type 3R signal head cannot be used when the opposing left turn is PPLT or permissive only and there is a single receiving lane (MUTCD 4D.05, F, 1).</p>
2-phase operation (operating as Protected/Permitted)	<p>One type 3RCF signal head, One Type 5 signal head, placed in the center of the projected lane lines.*. This operation should ONLY be used 1.) When using a 170 controller AND the conflicting crosswalk phase cannot be closed or 2.) When the opposing left turn is PPLT or permissive only and there is a single receiving lane (MUTCD 4D.05, F, 1). The type 5 signal head should no longer be used for new installations.</p>

* If possible, right-turn phase signal heads should be located within 6 to 12 feet of the nearest adjacent phase signal head.

Traffic-Roadway Section

Traffic Signal Design Manual – Proposed update type 3RCF signal head for PPRT

Replace existing Figure 5-33 (Signal Head Placement For Right-Turn Phasing) with the following figure highlighting the changes with yellow boxes outlined in blue:



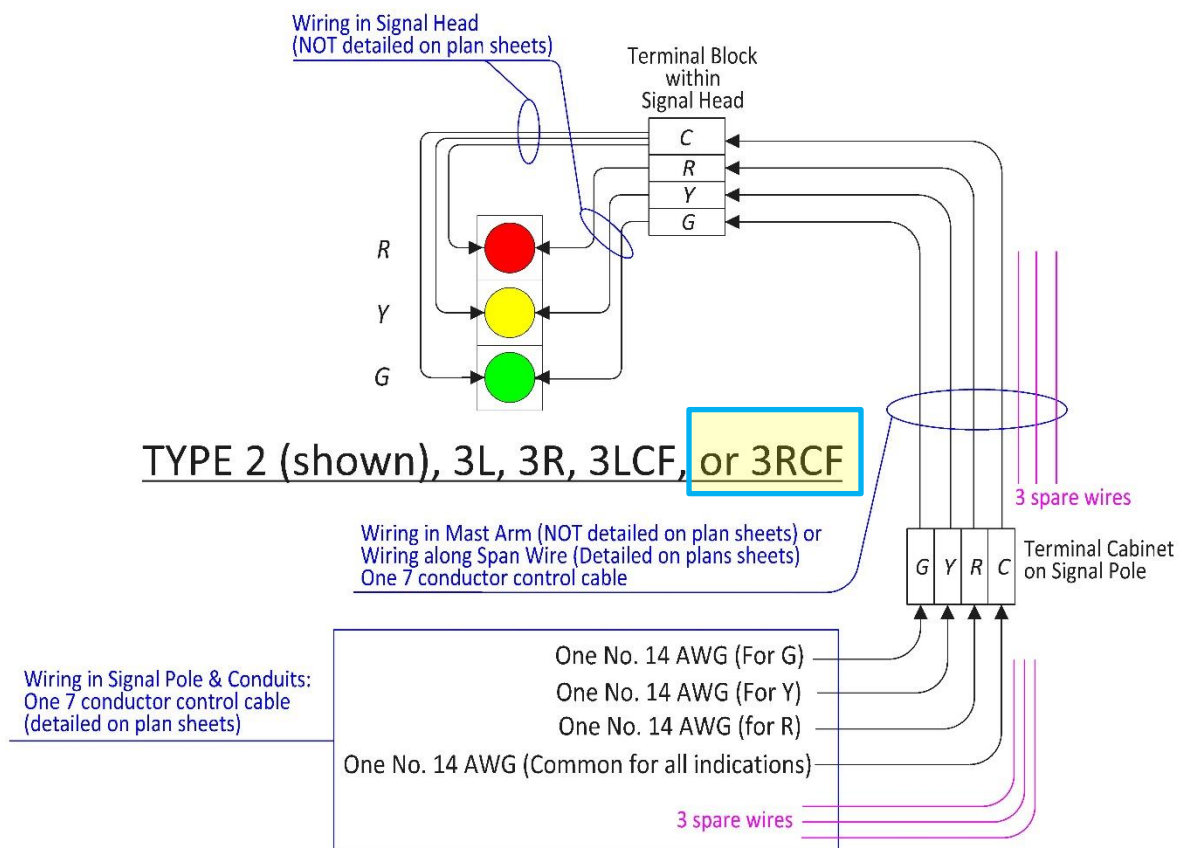
5.14 Wiring

5.14.6 Wiring Signal Heads (From Head to Terminal Cabinet)

Revise the following existing text as shown below in track changes:

Figure 5-106 shows the wiring required for a type 2, 3L, 3R, ~~or 3LCF~~, or 3RCF signal head. These signal head types contain one phase and three functions (Red, Yellow, and Green). The ~~3LCF signal head~~ yellow indication of the 3LCF signal head and 3RCF signal head performs two functions (flashing arrow and solid arrow) via software programming. One “hot” wire for each function and one common/neutral wire is required, resulting in ~~3~~ three spare wires.

Replace existing Figure 5-106 (Wiring for Type 2, 3L, 3R, and 3CLF signal heads. Rename figure to include 3RCF) with the following figure highlighting the changes with yellow boxes outlined in blue:



5.15 Background/Reference Information

5.15.4 Right-Turn Flashing Yellow Arrow (Type 3RCF Signal Head)

The current standard for protected/permitted right-right turn (PPRT) phasing uses a type 5 signal head which is not ideal for driver comprehension. Using a flashing yellow arrow for PPRT phasing instead has been shown to have greater understanding and improved yielding behavior of motorists to pedestrians ([Project SPR 789](#)). Replacing the type 5 signal head with the type 3RCF signal head provides the following additional benefits:

- Consistency with the current standard signal head for left-turn flashing yellow arrow (type 3LCF signal head)
- Fewer signal head types to maintain
- Less structural loading
- Displaying both the solid yellow arrow and the flashing yellow arrow from the same indication provides a safe and effective operation for road users as per [NCHRP research 20-07/Task 283](#). Additionally, experience using the type 3LCF signal heads for the left-turn flashing yellow arrow has been positive.

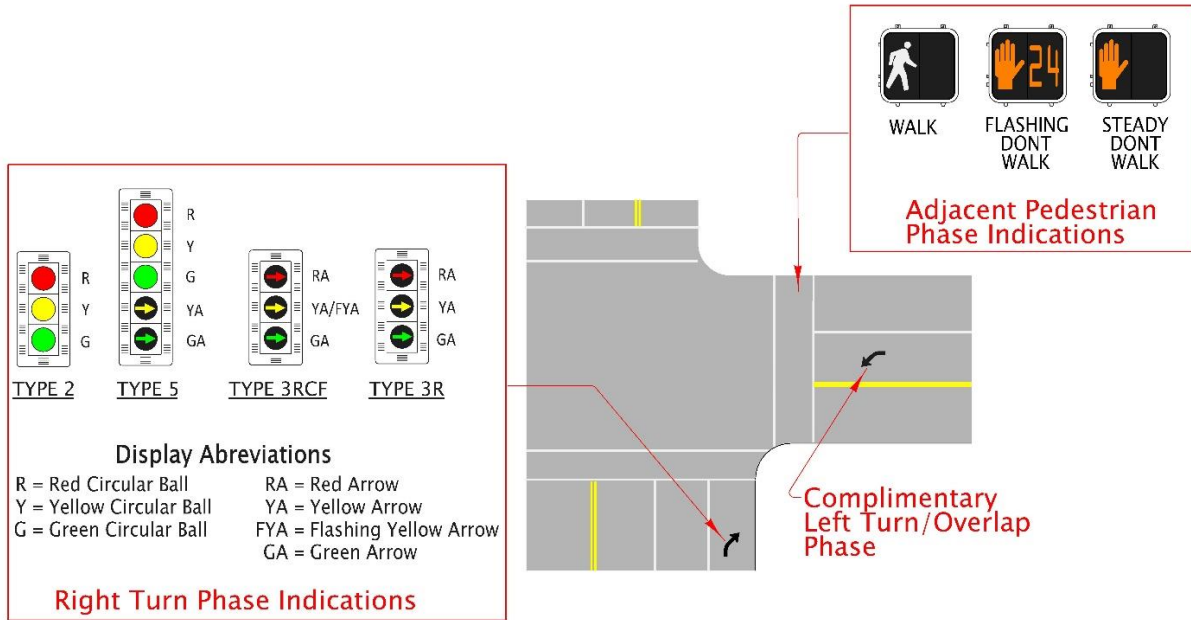
A type 6R signal head (equivalent to type 6L signal head for a left-turn flashing yellow arrow), while acceptable as an alternative signal head for PPRT phasing, is not the preferred signal head to use based on the listed benefits of the type 3RCF signal head.

The green arrow and the flashing yellow arrow of the type 3RCF signal head are required to be monitored as per section 20.7.3. This results in two separate outputs. There are only 16 monitored channels total, so using two channels for a type 3RCF signal head would drastically limit the intersections where it could be used. As such, a solution was developed by Region 1 traffic to combine the green arrow of type 3RCF signal head with the complimentary left-turn green arrow (both indications hard-wired to the same output) resulting in only one separate output to monitor for the type 3RCF signal head (the flashing yellow arrow). Custom software programming allows the type 3RCF signal head to operate appropriately (with the assigned outputs for each indication as shown in Chapter 20). This solution makes a standard for using the type 3RCF signal head feasible given the current limitations of the standard 332S cabinet hardware.

A right-turn flashing yellow arrow indication can be operated in various ways with respect to the adjacent pedestrian phase and complimentary left-turn phase. See Figure 5-1 for an illustration of the critical phase indications used in Table 5-1 and Table 5-1 for all the options that were evaluated.

Traffic Signal Design Manual – Proposed update type 3RCF signal head for PPRT





Figure 5-1 | Right-Turn Phase Indications and Associated Adjacent Pedestrian Phase Indications



Traffic-Roadway Section

Traffic Signal Design Manual – Proposed update type 3RCF signal head for PPRT

Table 5-1 | Right-Turn Only Lane Phasing Options Evaluated

Option	Phasing	Head Type		Typical Adjacent Pedestrian Phase Sequence:			
				Through Phase 	Through Phase 	Through Phase Steady 	Complimentary Left Turn Phase Steady 
1 (existing standard)	Permissive	2	Right-Turn Phase Signal Indication Sequence:	G	G	G	N/A
2	Permissive	?		FYA	FYA	FYA	N/A
3	Permissive: Partial Not-Ped	?		RA	FYA	FYA	N/A
4	Permissive: Not-Ped	?		RA	RA	FYA	N/A
5 (existing standard)	PPRT	5		G	G	G	GA
6	PPRT	3RCF		FYA	FYA	FYA	GA
7	PPRT: Partial Not-Ped	3RCF		RA	FYA	FYA	GA
8	PPRT: Not-Ped	3RCF		RA	RA	FYA	GA
9	PPRT	3RCF		FYA	FYA	GA	GA
10	PPRT	3RCF		FYA	FYA	GA	N/A
11	PPRT: Partial Not-Ped	3RCF		RA	FYA	GA	GA
12	PPRT: Partial Not-Ped	3RCF		RA	FYA	GA	N/A
13 (existing standard)	Protected (overlap): Not-Ped	3R		RA	RA	GA	GA
14	Protected: Not-Ped	3R		RA	RA	GA	N/A

Legend: G = Green Circular Ball, GA = Green Arrow, FYA = Flashing Yellow Arrow, RA = Red Arrow

PERMISSIVE ONLY OPTIONS

- **Option 1** is the current standard for permissive only phasing and will remain as the standard.
- **Options 2, 3, and 4** operate as permissive only phasing due to the lack of a green arrow indication and no complimentary left-turn phase. Permissive only phasing using a flashing yellow arrow (for both left and right turns) is not being considered as a standard or option at this point in time due to the limitations of the 332S controller

Traffic Signal Design Manual – Proposed update type 3RCF signal head for PPRT

cabinet hardware. Additionally, the appropriate signal head type for a permissive only flashing yellow arrow needs more consideration. However, there are rare cases where permissive only phasing using a flashing yellow arrow may be the best solution for certain unique lane configurations and phasing (See example of Van Buren Ave at 1st Street in Corvallis: no complementary left-turn phase, a bike lane located to the right of the right-turn only lane controlled with a bike phase, and recalled pedestrian phases.) Contact the State Traffic Signal Engineer and State Traffic Operations Engineer for a discussion/evaluation of operational options and approval of use of a flashing yellow arrow for permissive only phasing.

PROTECTED/PERMITTED (PPRT) OPTIONS

- **Option 5** is the current standard for PPRT phasing. This option will no longer be used for new construction. Options 6, 7 and 8 will replace option 5.
- **Option 6** provides a good balance of relative simplicity of timing/conflict monitoring, improved intersection efficiency while improving motorist yielding behavior to the pedestrian. This option also is best way to allow pedestrian re-service or serve a late pedestrian call.
- **Option 7 & 8** provide a good balance of relative simplicity of timing/conflict monitoring, improved intersection efficiency while improving motorist yielding behavior to the pedestrian plus increased protection of the pedestrian phase (via either a partial not-ped or full not-ped). Protection of the pedestrian phase makes these options difficult to re-service the pedestrian phase or serve a late pedestrian call which can lead to longer pedestrian delay and may increase jaywalking. Also, if the PPRT has an opposing permissive left-turn, use of a true leading pedestrian interval may be desirable/necessary to protect pedestrian phase from both left and right turning movements. Washington County has had positive experience using option 8.
- **Options 9 and 11** are problematic for the green arrow software/output configuration and added complexity to the conflict monitoring. For these reasons, these two options are infeasible.
- **Options 10 and 12** do not operate as a true PPRT or overlap due to the lack of a complimentary left-turn phase. Its only purpose is to use a flashing yellow arrow indication instead of a green ball or provide a partial not-ped function; there is no operational benefit. In addition, the flashing yellow arrow operation of options 10 and 12 match the flashing yellow operation of options 9 and 11 which is problematic for the software/output configuration and conflict monitoring. For these reasons, these two options are infeasible. Acceptable alternatives to options 10 and 12 (to address safety concerns related to pedestrians and right turning vehicles) include using standard permissive only right-turn phasing with a leading ped interval or using protected only phasing (option 14).

Traffic-Roadway Section





Traffic Signal Design Manual – Proposed update type 3RCF signal head for PPRT

PROTECTED ONLY OPTIONS

- **Option 13** is the current standard for protected only phasing and will remain as the standard.
- **Option 14** does not operate as a true overlap due to the lack of a complimentary left turn phase. Its only purpose is to provide a not-ped function; there is no operational benefit. This option should be used with caution as the green arrow indication in the “steady don’t walk through phase” could be skipped or very short after a pedestrian phase.

Table 5-2 summarizes the resulting new standard for all forms of right-turn phasing. The final result is a balance of simplicity, increased protection of the pedestrian phase, and efficiency for the vast majority of intersections.

Table 5-2 | Right-Turn Only Phasing - New Standard

Phasing	Head Type	Typical Adjacent Pedestrian Phase Sequence:				
		Through Phase 	Through Phase 	Through Phase Steady 	Complimentary Left Turn Phase Steady 	
Permissive	2	Right Turn Phase Signal Indication Sequence:	G	G	G	N/A
PPRT	3RCF		FYA	FYA	FYA	GA
PPRT: Partial Not-Ped	3RCF		RA	FYA	FYA	GA
PPRT: Not- Ped	3RCF		RA	RA	FYA	GA
Protected (overlap): Not-Ped	3R		RA	RA	GA	GA
Protected: Not-Ped	3R		RA	RA	GA	N/A

Traffic Signal Design Manual – Proposed update type 3RCF signal head for PPRT

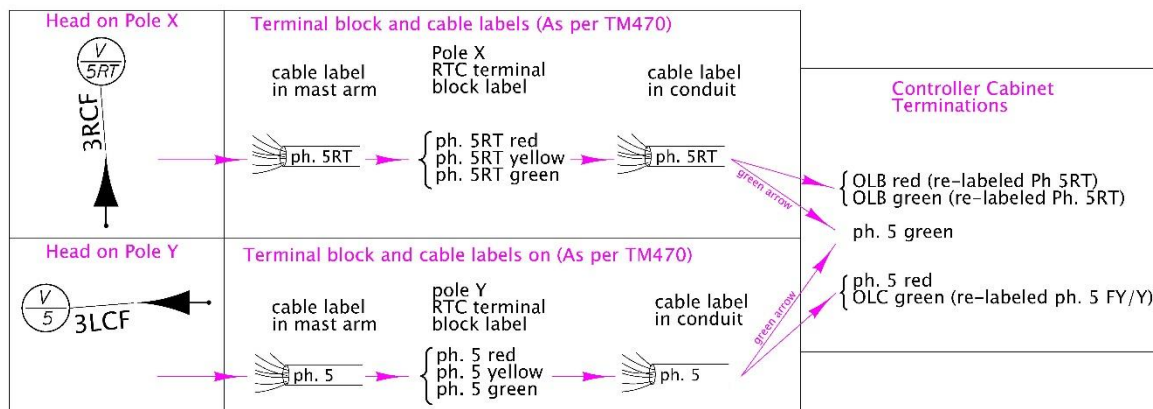
LABELING THE PPRT PHASE

Labeling the PPRT phase as the complementary left-turn phase followed by “RT” (e.g., 1RT, 3RT, 5RT, or 7RT) is necessary to avoid confusion and potential errors associated with labeling the terminal blocks and control cables (both during initial installation and maintenance). Using just the complementary left-turn phase for the type 3RCF signal head (e.g., 1, 3, 5, or 7) as what is typically done for a PPLT phase, or using a dual phase notation as what is typically done for the type 5 signal head (e.g. 4/5, 1/8, etc.) is problematic for the following reasons:

- Using 1, 3, 5, or 7 for a right-turn signal head is not intuitive as the odd phases are typically left-turn phases and not normally associated with right-turn phases. PPLT doesn’t have this confusion, because it is still a left-turn phase and normally associated with the odd phases.
- It is confusing when two cables labeled “ph 3” (one for the actual left-turn phase and one for the type 3RCF signal head) enter the controller cabinet and they require slightly different terminations.
- Using a dual phase notation for the PPRT that combines the phases of the protected portion and the permissive portion causes extra confusion as type 3RCF signal head should NOT be terminated to the adjacent thru phase in the pole terminal cabinet (as a type 5 signal head would).

Using a completely new and different phase for the type 3RCF head makes it very clear how to label the cables and terminal blocks and aids in properly identifying each cable/termination easily during trouble shooting. See Figure 5-2. **NOTE: if there is no complementary left turn phase number due to split phasing (see chapter 3 for more info), the PPRT phase will be labeled with the split phasing number followed by “RT” (e.g. 2RT, 4RT, 6, RT, or 8RT)**

Figure 5-2 | Labeling of Terminal Blocks and Cables for Type 3RCF Signal Head



20 Cabinet Print

20.7 Cabinet Print (Page 3 – Output File)

20.7.3 Conflict Monitor Diode Card

Revise the following existing text as shown below in track changes:

When using flashing yellow arrow the following rules apply (for additional background information see Section 20.12.1 and Section 5.15.4):

- The **left-turn** flashing yellow arrow signal head type shall be a type 3LCF:
 - Phase 1 FYA = Channel 9
 - RED arrow terminated on ph. 1 RED
 - FYA/solid YELLOW arrow terminated on OLA GREEN
 - GREEN arrow terminated on ph. 1 GREEN
 - Phase 3 FYA = Channel 10
 - RED arrow terminated on ph. 3 RED
 - FYA/solid YELLOW arrow terminated on OLB GREEN
 - GREEN arrow terminated on ph. 3 GREEN
 - Phase 5 FYA = Channel 11
 - RED arrow terminated on ph. 5 RED
 - FYA/solid YELLOW arrow terminated on OLC GREEN
 - GREEN arrow terminated on ph. 5 GREEN
 - Phase 7 FYA = Channel 12
 - RED arrow terminated on ph. 7 RED
 - FYA/solid YELLOW arrow terminated on OLD GREEN
 - GREEN arrow terminated on ph. 7 GREEN
- The **right-turn** flashing yellow arrow signal head type shall be a type 3RCF:
 - Phase 1 RT = Channel 9
 - RED arrow terminated on OLA RED
 - RFYA/solid YELLOW arrow terminated on OLA GREEN
 - GREEN arrow terminated on ph. 1 GREEN
 - Phase 3 RT = Channel 10
 - RED arrow terminated on OLB RED
 - RFYA/solid YELLOW arrow terminated on OLB GREEN
 - GREEN arrow terminated on ph. 3 GREEN
 - Phase 5 RT = Channel 11
 - RED arrow terminated on OLC RED
 - RFYA/solid YELLOW arrow terminated on OLC GREEN
 - GREEN arrow terminated on ph. 5 GREEN

Traffic Signal Design Manual – Proposed update type 3RCF signal head for PPRT

- Phase 7 RT = Channel 12
 - RED arrow terminated on OLD RED
 - RFYA/solid YELLOW arrow terminated on OLD GREEN
 - GREEN arrow terminated on ph. 7 GREEN

If there is no protected left turn phase number for the PPRT due to split phasing (see chapter 3 for more info), the field terminations for the flashing right turn arrow shall instead be as follows:

- Phase 2 RT = Channel 9
 - RED arrow terminated on OLA RED
 - RFYA/solid YELLOW arrow terminated on OLA GREEN
 - GREEN arrow terminated on ph. 2 GREEN
- Phase 4 RT = Channel 10
 - RED arrow terminated on OLB RED
 - RFYA/solid YELLOW arrow terminated on OLB GREEN
 - GREEN arrow terminated on ph. 4 GREEN
- Phase 6 RT = Channel 11
 - RED arrow terminated on OLC RED
 - RFYA/solid YELLOW arrow terminated on OLC GREEN
 - GREEN arrow terminated on ph. 6 GREEN
- Phase 8 RT = Channel 12
 - RED arrow terminated on OLD RED
 - RFYA/solid YELLOW arrow terminated on OLD GREEN
 - GREEN arrow terminated on ph. 8 GREEN

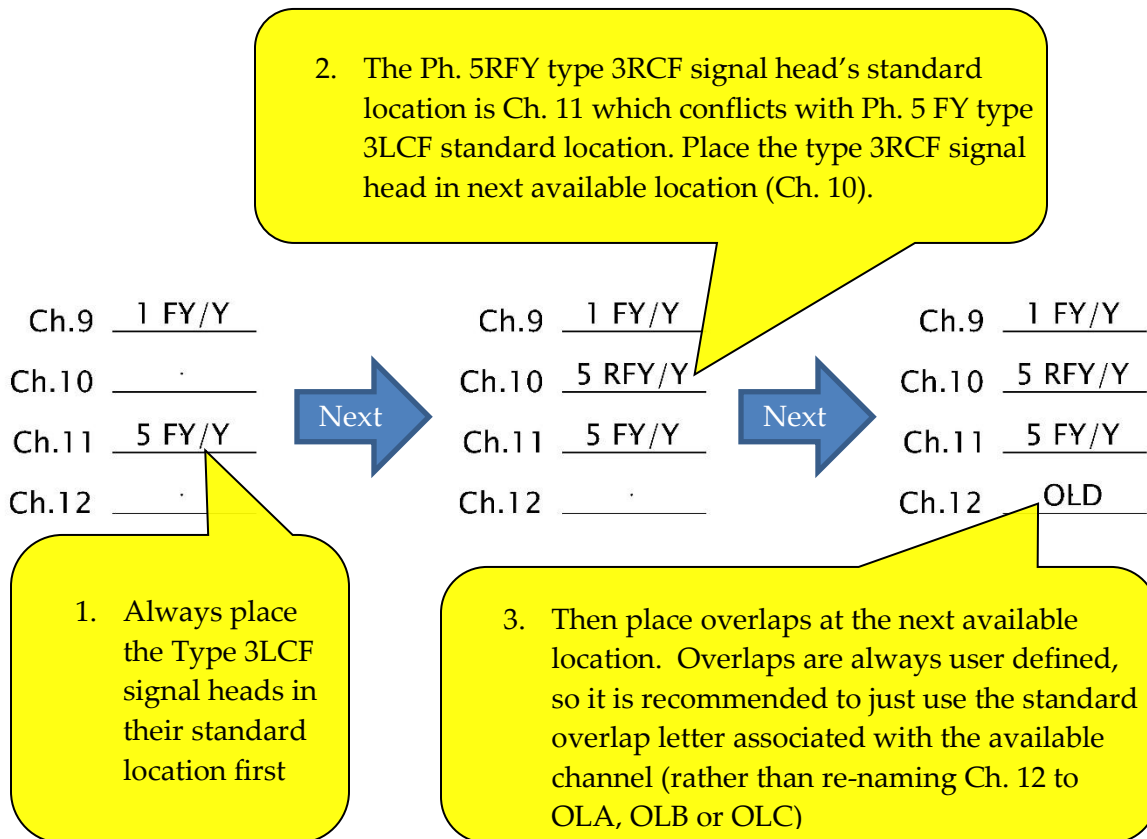
Traffic Signal Design Manual – Proposed update type 3RCF signal head for PPRT

Channel Assignment – Output Reassignment Order of Priority for FYA phases & overlap phases

If there is a combination of left-turn flashing yellow arrows, right-turn flashing yellow arrows, and overlap phases at the same intersection, use the following order of priority to rearrange the auxiliary outputs (Ch. 9 through Ch. 12) when the standard switch pack locations for the Type 3LCF signal heads, Type 3RCF signal heads, and overlap signal heads conflict. See Figure 20-1:

1. Place the type 3LCF signal head outputs first in their standard output locations.
2. Next, place the type 3RCF signal head outputs in their standard output locations if possible. If not possible due to a conflict with a type 3LCF signal head output, place the type 3RCF signal head outputs in the next available unused overlap switch pack locations.
3. Next, place the overlap signal head outputs in the next available unused overlap switch pack locations.

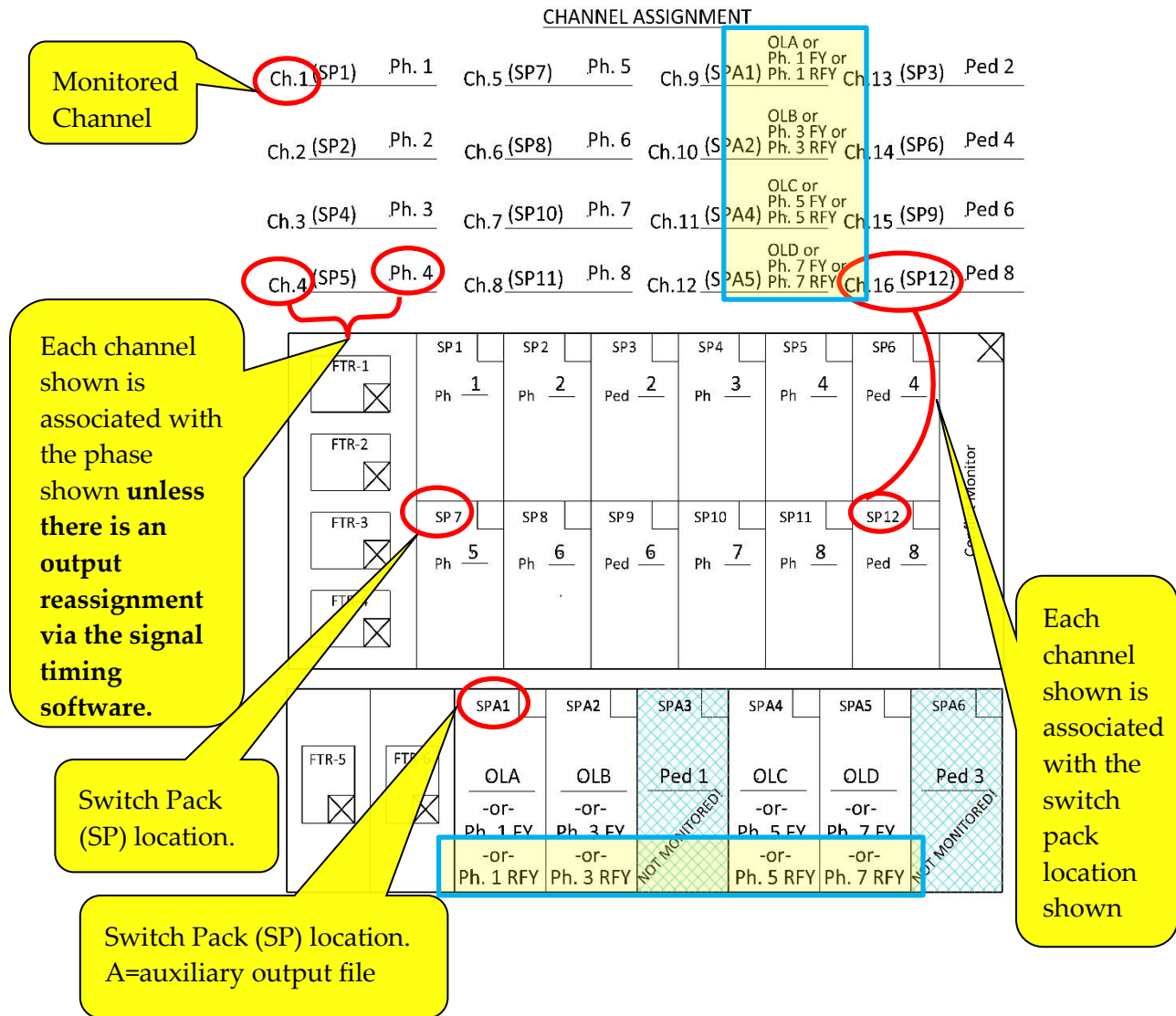
Figure 20-1 | Order of priority for standard placement of type 3LCF signal heads, type 3RCF signal heads, and overlap signal heads in the auxiliary output file



Traffic-Roadway Section

Traffic Signal Design Manual – Proposed update type 3RCF signal head for PPRT

Replace existing Figure 20-20 (Standard Channel Assignment) with the following figure highlighting the changes with yellow boxes outlined in blue:



20.7.5 Additional Information for the Output File

Revise the following existing bullet point as shown below in track changes:

- The conflict monitor is limited to a total of 16 channels which limits the number of phases that can be used at an intersection. The flashing yellow arrow indication (for a protected/permitted left **or right** turn phase) is assigned to the channels normally reserved for overlap phases. As such, the number of protected/permitted left **or right** turn phases and vehicle overlap phases at an intersection will be limited to a combined total of four. For example, typical maximum combinations an intersection can have:
 - PPLT for phases 1, 3, 5, and 7 with NO overlap phases **and NO PPRT**
 - **PPRT for four phases with NO PPLT and NO overlap phases**
 - Four overlap phases with NO PPLT **and NO PPRT**
 - PPLT for phases 1 and 5 with two overlap phases **and NO PPRT**
 - PPLT for phases 3 and 7 with two overlap phases **and NO PPRT**
 - **PPLT for phases 1 and 5 with PPRT for two phases and NO overlap phases**

Exceptions to combined total of four may be acceptable in the rare circumstance where there is an unused vehicle phase output that an overlap phase can be reassigned to (channels 1 thru 8). The flashing yellow arrow indications should only be wired to channels 9 thru 12 as shown in Figure 20-20.

Assigning **the left-turn** flashing yellow arrow to pedestrian yellow outputs will no longer be allowed as it can result in problematic conflict monitoring when used in conjunction with overlaps, not-ped phasing and type 3LCF signal heads. See Section 20.12.1 for additional background/reference info.

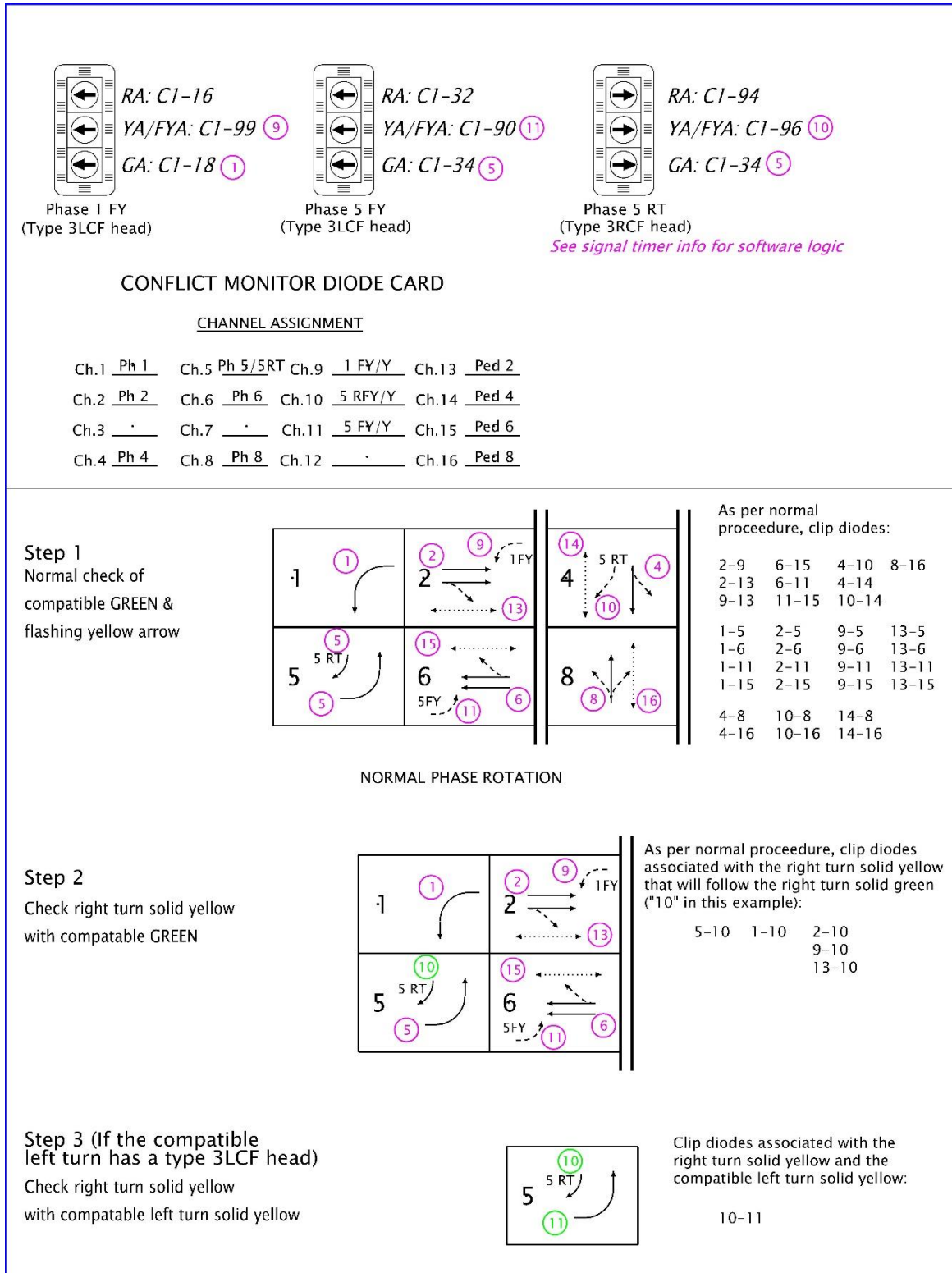
20.7.7 Output File & Conflict Monitor Configuration For Right-Turn Flashing Yellow Arrow (Type 3RCF Signal Head)

Figure 20-2 through Figure 20-4 shows examples of various configurations using right-turn flashing yellow arrow (type 3RCF signal head) and the unique process that must be used to properly configure the conflict monitor.

Traffic-Roadway Section

Traffic Signal Design Manual – Proposed update type 3RCF signal head for PPRT

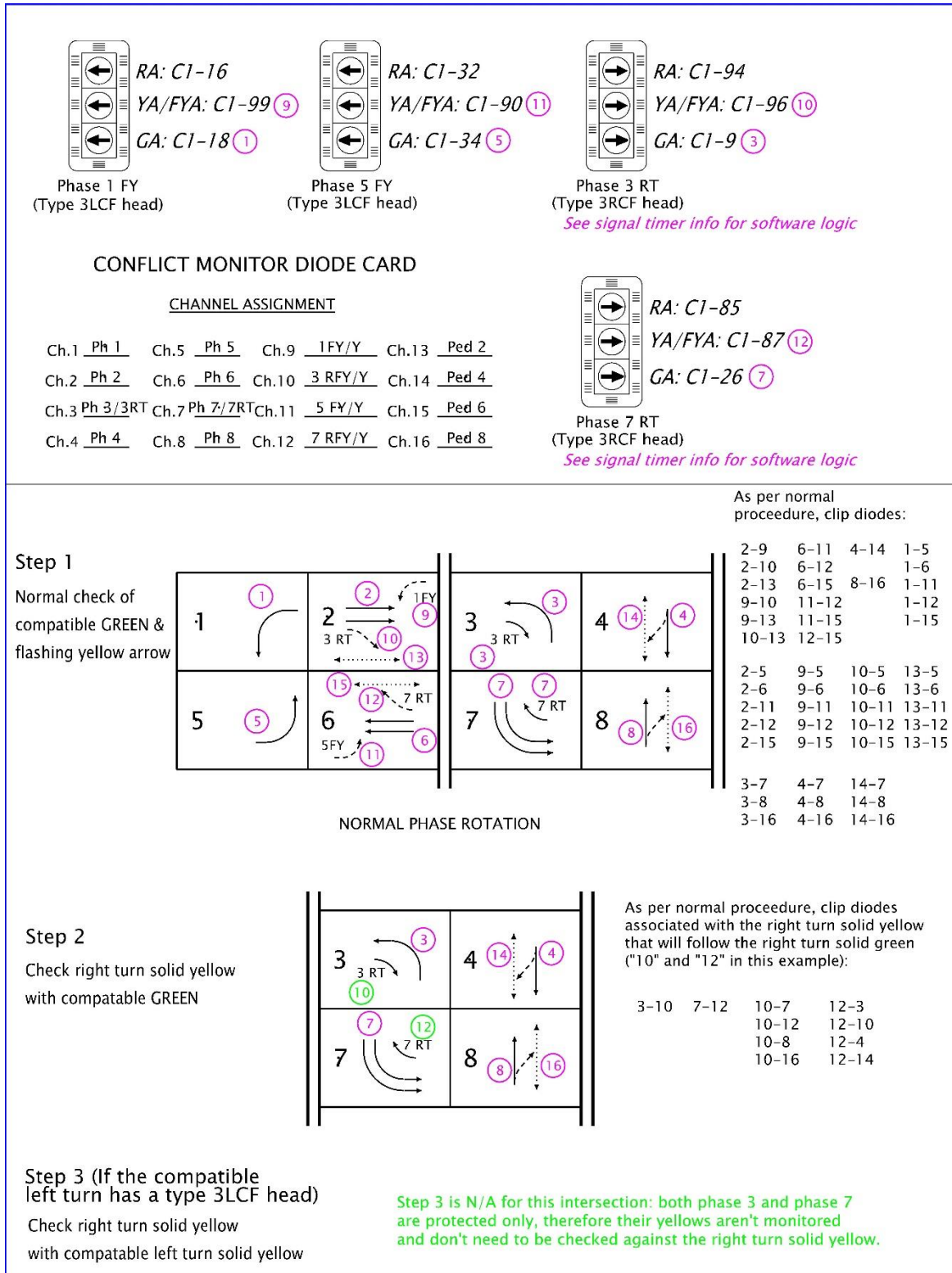
Figure 20-2 | Determining Compatible Phases – Example 1: Right-Turn Flashing Yellow Arrow and Left-Turn Flashing Yellow Arrow



Traffic-Roadway Section

Traffic Signal Design Manual – Proposed update type 3RCF signal head for PPRT

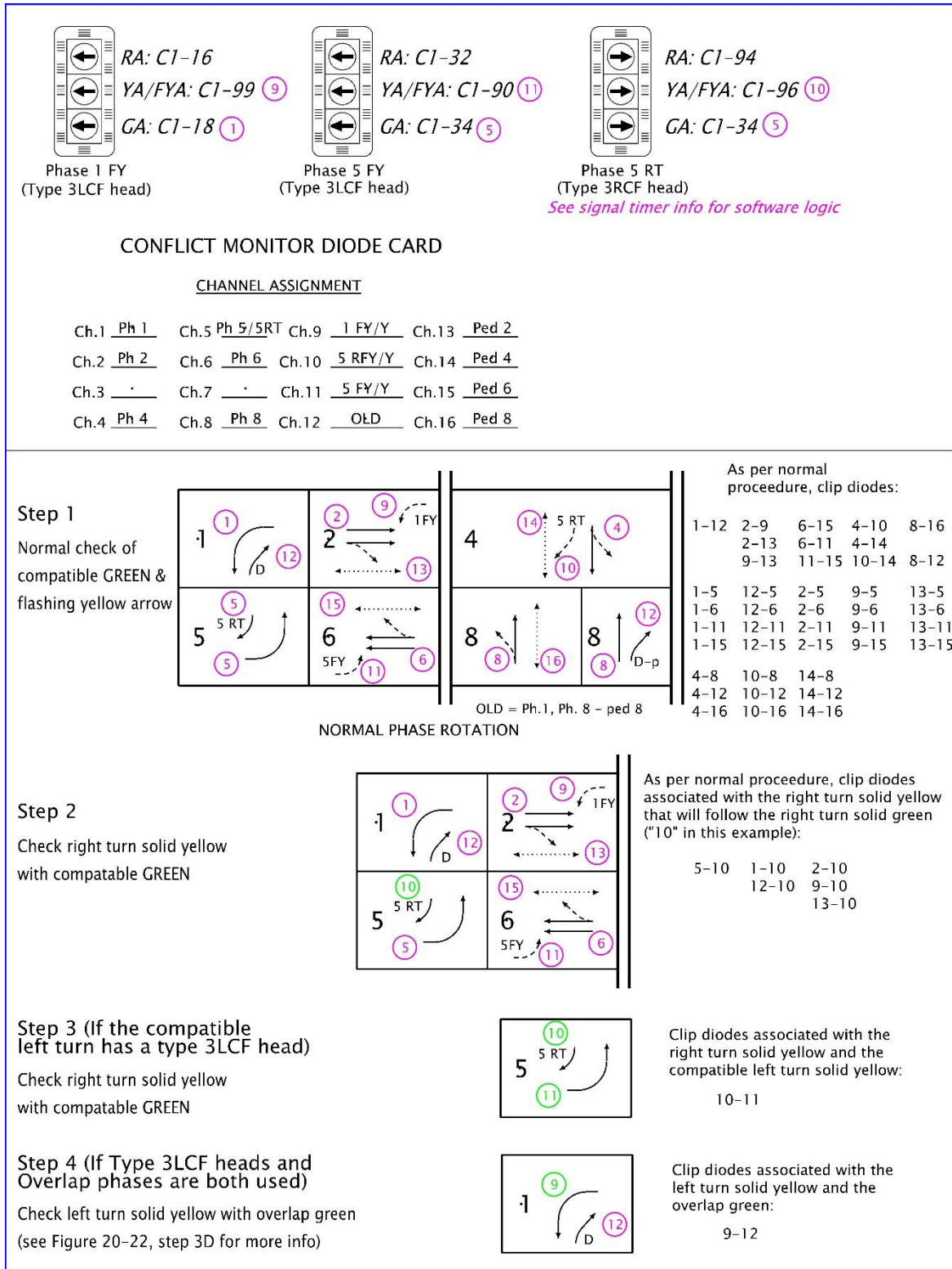
Figure 20-3 | Determining Compatible Phases – Example 2: Right-Turn Flashing Yellow Arrow and Left-Turn Flashing Yellow Arrow



Traffic-Roadway Section

Traffic Signal Design Manual – Proposed update type 3RCF signal head for PPRT

Figure 20-4 | Determining Compatible Phases – Example 3: Right-Turn Flashing Yellow Arrow, Left-Turn Flashing Yellow Arrow, AND Overlap Phase



21 Traffic Signal Policy and Guidelines

Consider the following text for inclusion into the Traffic Signal Policy and Guidelines based on the above new design standards:

PERMISSIVE ONLY – The most common right-turn mode. Right-turn movements are served concurrently with the corresponding through movements, but right-turn movements must yield to the conflicting pedestrian movements. This is the default right-turn phasing unless an engineering study shows PPRT or protected (overlap) phase meets the required conditions.

If there are pedestrian safety concerns but the conditions for protected only (overlap) or PPRT cannot be met, permissive only right-turn phasing with a leading pedestrian interval should be used. Exceptions to the protected only (overlap) or PPRT conditions will be considered if an engineering study documents:

- The implementation of the leading ped interval did not have the desired effect
- The proposed timing and output configuration of right-turn signal head is tested and approved by TSSU

PROTECTED ONLY (OVERLAP) – Shall meet all of the following conditions:

- The subject right-turn movement is served by one or more exclusive right-turn lanes.¹
- Opposing left-turn movement phasing and receiving lane configuration is MUTCD compliant (e.g., the opposing left-movement has protected only phasing OR the opposing left-movement and the subject right-turn movement each have a separate, defined receiving lane).
- U-turns from the complementary left-turn are prohibited.¹

And shall meet either of the following conditions:

- A significant number of right-turn vehicle-pedestrian crashes, frequent near-miss conflicts are reported/observed, or risk to vulnerable users is high. Follow the requirements stated in the Highway Safety Manual (HSM) and NCHRP 20-44(13) IMPLEMENTATION OF NCHRP RESEARCH REPORT 893: THE OREGON DOT STATEWIDE PEDESTRIAN AND BICYCLE PLAN to analyze crash data, determine risk, and quantify the benefit to the vulnerable user.
- The right-turn volume is high (300 vehicles per hour or more) and is a critical movement at the intersection.¹

The standard practice for operating a protected right-turn signal at a location with a crosswalk adjacent to the right-turn lane is to assign the right-turn signal to an overlap phase that will not

¹ FHWA Traffic Signal Timing Manual

Traffic-Roadway Section

Traffic Signal Design Manual – Proposed update type 3RCF signal head for PPRT

permit a green indication concurrently during the walk or flashing don't walk pedestrian intervals for the adjacent crosswalk. This is known as "not-ped" overlap.





PROTECTED/PERMITTED (PPRT) – Shall meet all the following conditions:

- All conditions listed for protected only (overlap) phasing are met. Exception: MUTCD compliant phasing/receiving lane configuration is NOT required to be met.
- A protected left-turn phase is provided for the complementary left-turn movement on the intersecting road.

And shall meet either of the following conditions:

- A type 3R signal head (protected only phasing) would not be MUTCD compliant due to an opposing permissive or PPLT left turn with a single receiving lane.
- Significant use of the adjacent pedestrian phase would render a protected overlap phase virtually useless during the through phase.

There are three timing options for the operation of PPRT phasing; basic, partial not-ped, and not-ped. See table below. Each option provides a different level of protection to the adjacent pedestrian phase and has certain operational considerations as noted. Engineering judgement should be used to determine which timing option balances the site specific needs best (vehicle efficiency/queues vs. pedestrian phase protection).

PPRT Phasing	Head Type	Right-Turn Phase Signal Indication Sequence:	Typical Adjacent Pedestrian Phase Sequence:				Operational Considerations
			Thru Phase 	Thru Phase 	Thru Phase Steady 	Complimentary left turn phase Steady 	
PPRT: Basic	3RCF		FYA	FYA	FYA	GA	Allows for ped re-service and service of late pedestrian calls (can help decrease pedestrian delays and lower likelihood of jaywalking)
PPRT: Partial Not-Ped	3RCF		RA	FYA	FYA	GA	If the PPRT's opposing left turn is permissive, also consider using a true leading ped interval to protect the pedestrian phase from both the left and right-turn movements.
PPRT: Not- Ped	3RCF		RA	RA	FYA	GA	Ped re-service and service of late pedestrian calls is not allowed.