Optimizing Cycle Length and Green Time For A Signalized Intersection

Introduction

- Signals are the best solution for efficiently directing more than one-way traffic without relying on human presents

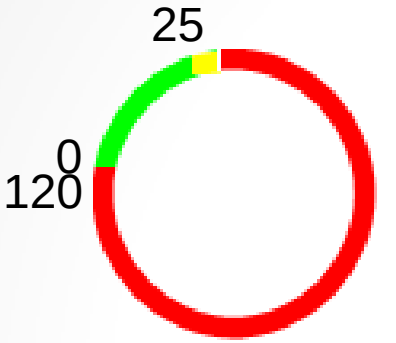
- It is also important to efficiently design a traffic signal

Introduction
Factors involved in signal design

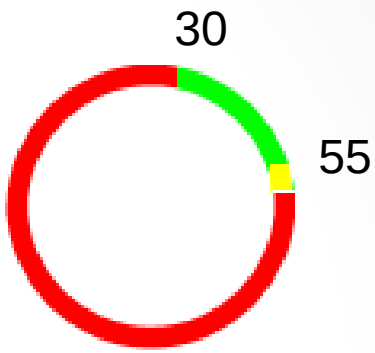
- Cycle length (C)
- Phase (ϕ)
- Green time (g)
- Lost time (L)

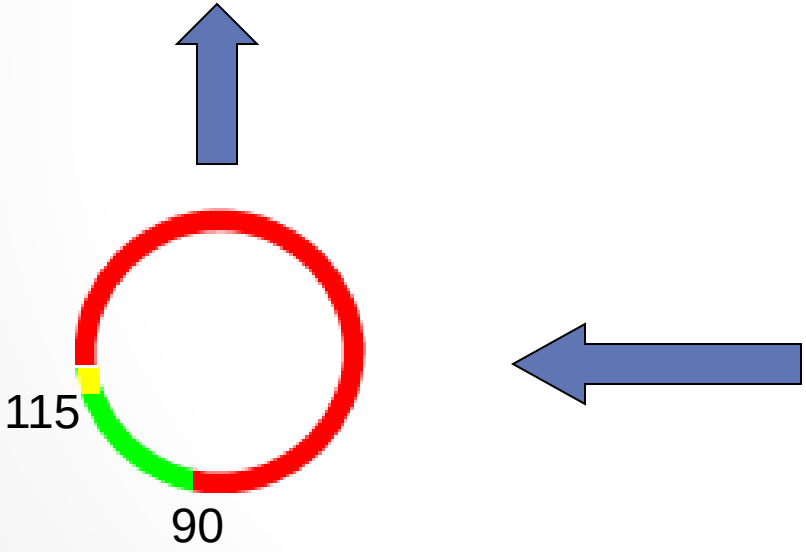
Total lost in a phase (t_L : $t_{sl} + t_{cl}$)

Phase 1 (Φ1): EBL+WBL
Green time: 0 to 25 sec

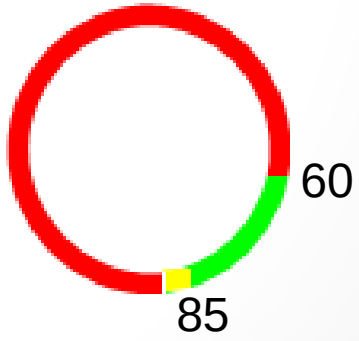


Phase 2 (Φ2): EBT/R+WBT/R
Green time: 30 to 55 sec





Phase 4 (Φ4): NBT/R+SBT/R
Green time: 90 to 115 sec

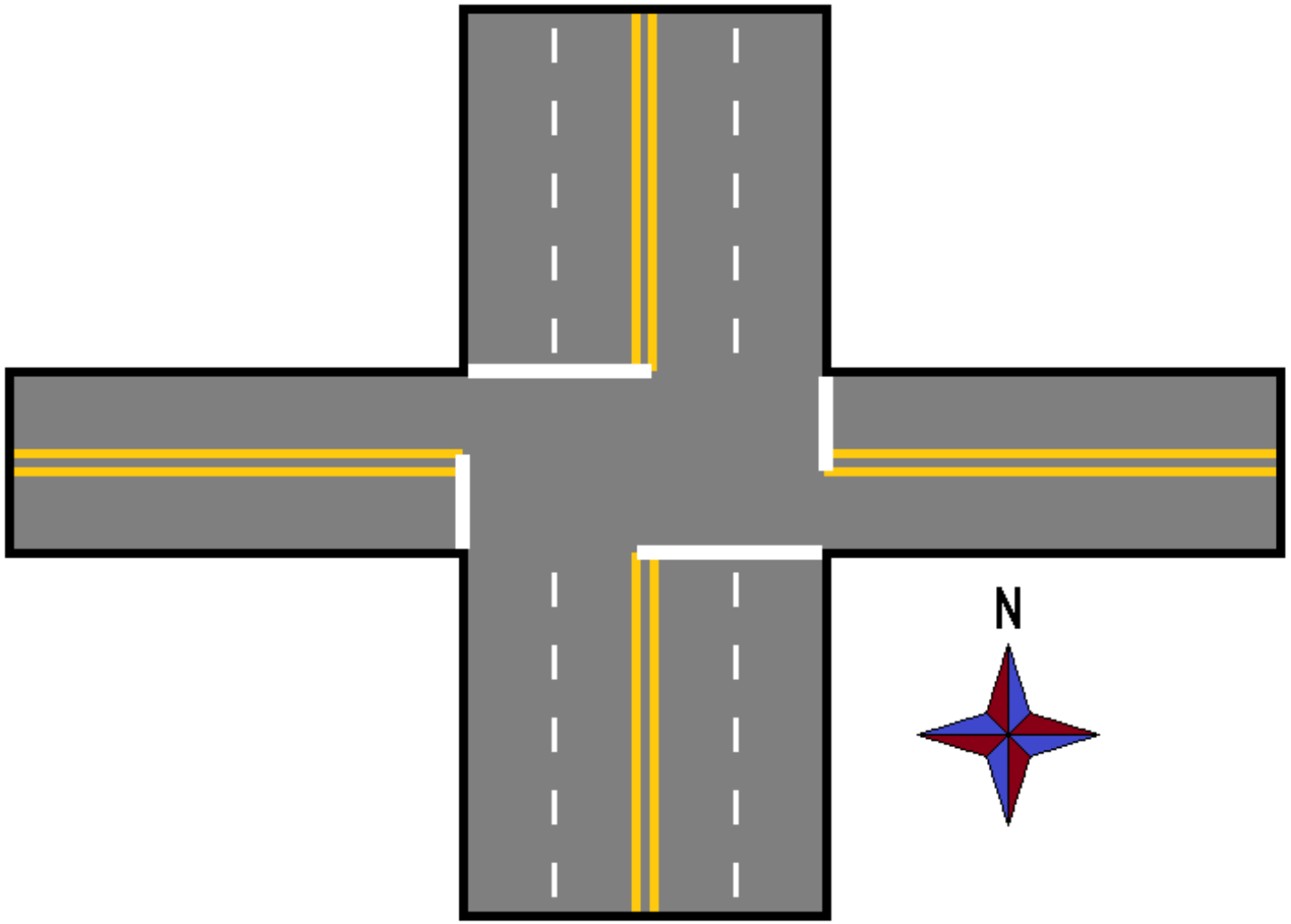


Phase 3 (Φ3): NBL+SBL
Green time: 60 to 85 sec

Introduction

Factors involved in signal design

- Saturation flow rate (s)
- Analysis flow rate (v)
- Critical lane group (v/s)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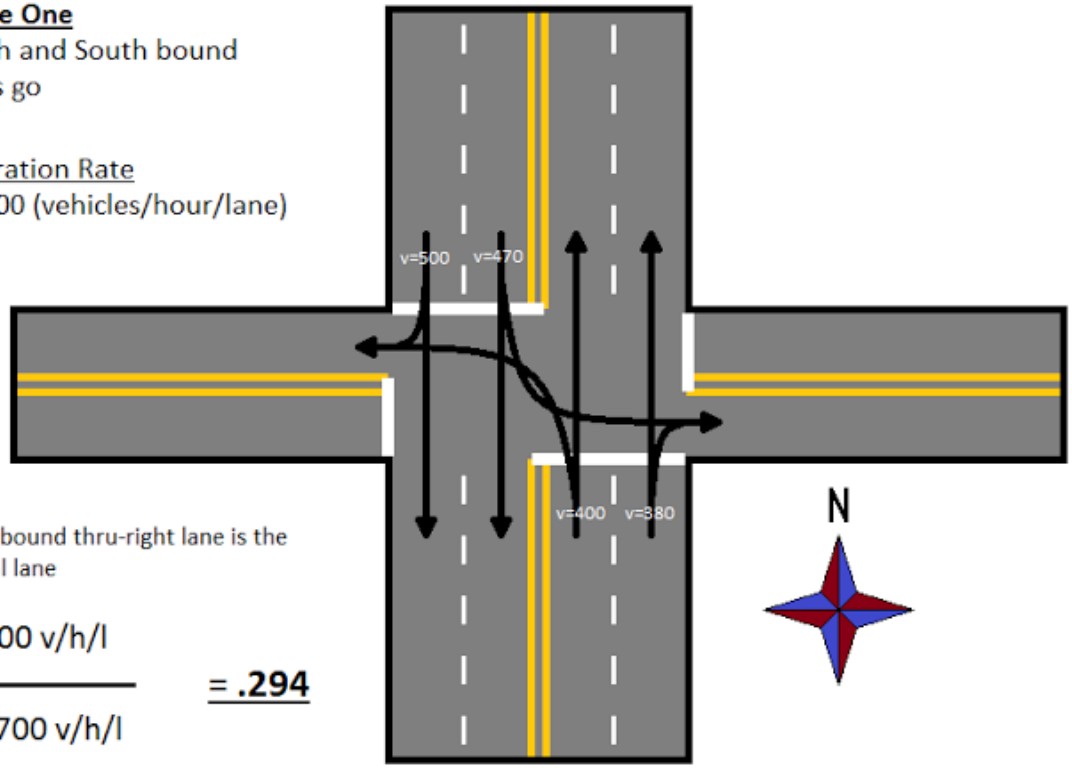
Methodology

Phase 1 North-South

Phase One
North and South bound lanes go

Saturation Rate
s=1700 (vehicles/hour/lane)



Southbound thru-right lane is the critical lane

$$\frac{v = 500 \text{ v/h/l}}{s = 1700 \text{ v/h/l}} = .294$$

Methodology

Phase 1 North-South analysis and saturation flow rates

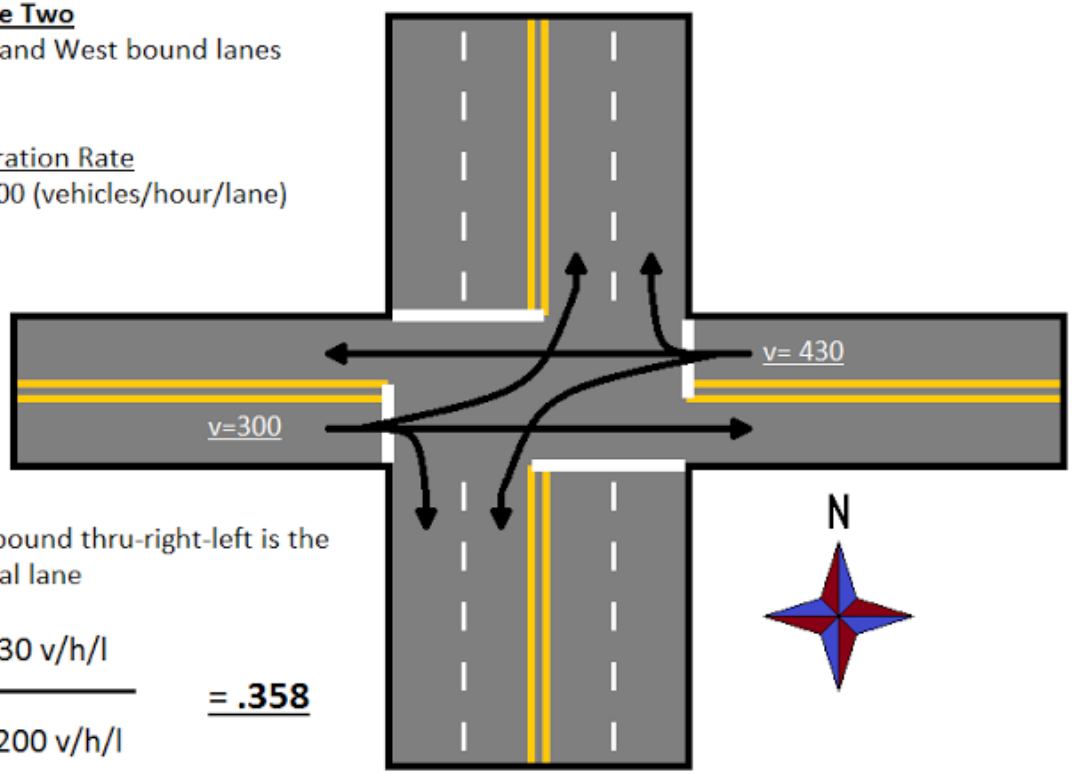
- North-bound thru and right (v)NBT/R = 380 vehicles per hour per lane (vphpl)
- North-bound thru and left (v)NBT/L = 400 vehicles per hour per lane (vphpl)
- South-bound thru and right (v)SBT/R = 500 vehicles per hour per lane (vphpl)
- South-bound thru and left (v)SBT/L = 470 vehicles per hour per lane (vphpl)
- Saturation rate for all lanes (s) = 1700 vehicles per hour per lane (vphpl)

Methodology

Phase 2 East-West

Phase Two
East and West bound lanes go

Saturation Rate
s=1200 (vehicles/hour/lane)



Eastbound thru-right-left is the critical lane

$$\frac{v = 430 \text{ v/h/l}}{s = 1200 \text{ v/h/l}} = .358$$

Methodology

Phase 2 East-West

- East-bound thru, right, left (v)EBT/R/L = 300 vehicles per hour per lane (vphpl)
- West-bound thru, right, left (v)WBT/R/L = 430 vehicles per hour per lane (vphpl)
- Saturation rate for all lanes (s) = 1200 vehicles per hour per lane (vphpl)

Methodology

Critical lane group determination (v/s) phase 1

(v/s)PHASE 1 = MAX {(v/s)NBT/R, (v/s)NBT/L, (v/s)SBT/R, (v/s)SBT/L}

= MAX {(380/1700), (400/1700), (500/1700), (470/1700)}

= MAX {0.224, 0.235, 0.294, 0.2766}

= **0.294 SBT/R is the critical lane group in phase 1**

Methodology

Critical lane group determination (v/s) phase 2

(v/s)PHASE 2 = MAX {(v/s)EBT/R/L, (v/s)WBT/R/L}

= MAX {(300/1700), (430/1200)}

= MAX {0.25, 0.358}

= **0.358 WBT/R/L is the critical lane group in phase 2**

Methodology

Sum of critical lane groups

- $\Sigma(v/s)Ci = (v/s)PHASE\ 1 + (v/s)PHASE\ 2$

$= 0.294 + 0.358$

$= \mathbf{0.652}$

Methodology

Optimum Cycle Length (C_{opt})

$C_{opt} = [1.5 \times L + 5] / (1 - \Sigma(v/s)Ci)$

$C_{opt} = [(1.5 \times 8) + 5] / (1 - 0.652)$

$C_{opt} = 17 / 0.348$

$C_{opt} = 48.85$ seconds

$C_{opt} =$ **49 seconds**

Methodology
Green Time Phase 1

gi = ((v/s)Ci /Σ(v/s)Ci) X (C - L)

= (0.294/0.652) X(49-8)

= 18.48 seconds

= ***18 seconds***

Methodology
Green Time Phase 2

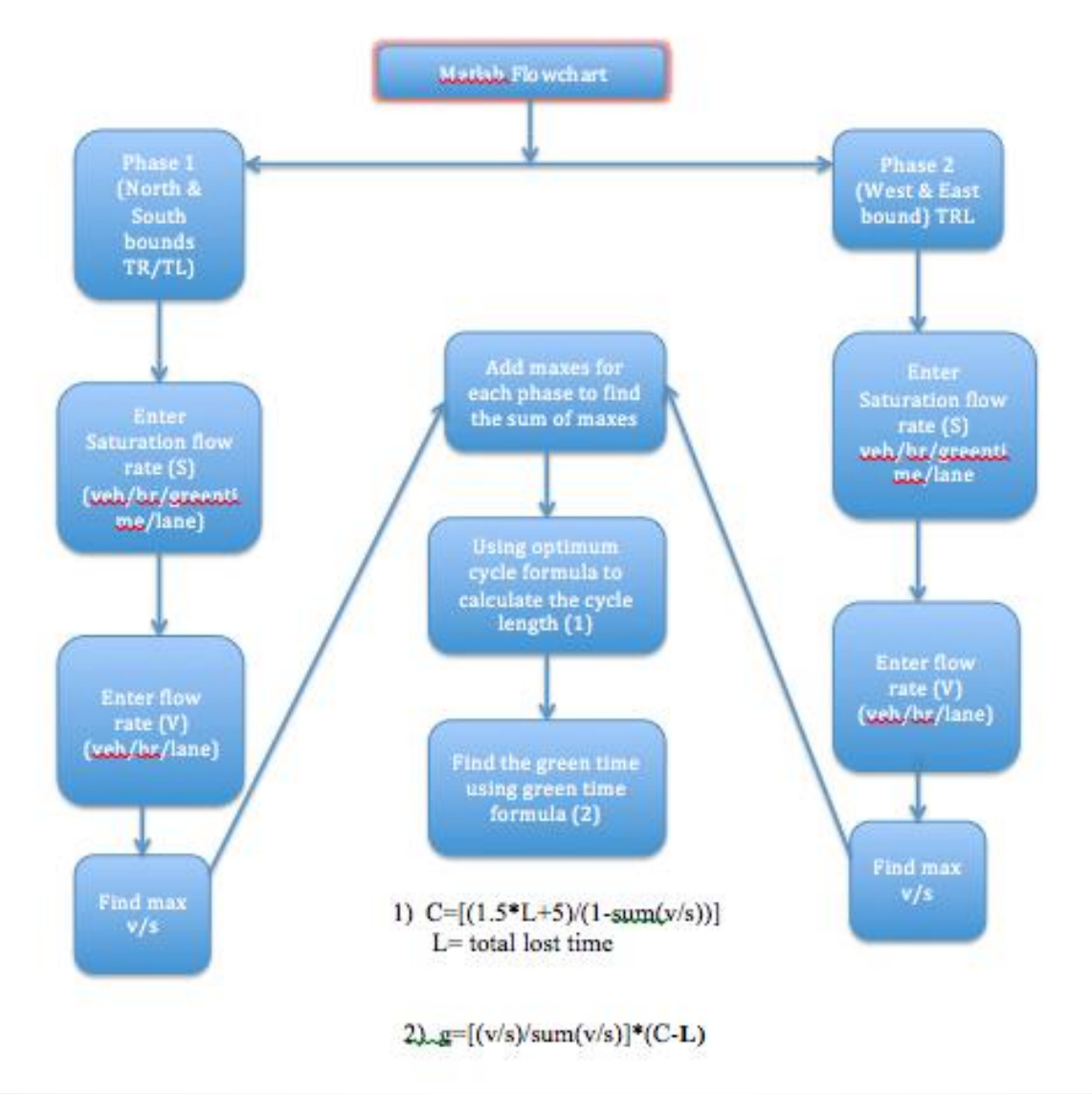
gi = ((v/s)Ci /Σ(v/s)Ci) X (C - L)

= (0.358/0.652) X 49-8

= 22.52 seconds

= ***23 seconds***

Flowchart


Matlab Flowchart
Phase 1 (North & South bounds TR/TL)
Phase 2 (West & East bound) TRL
Enter Saturation flow rate (S) (veh/hr/greenti me/lane)
Enter Saturation flow rate (S) veh/hr/greenti me/lane
Add maxes for each phase to find the sum of maxes
Using optimum cycle formula to calculate the cycle length (1)
Find the green time using green time formula (2)
Enter flow rate (V) (veh/hr/lane)
Enter flow rate (V) (veh/hr/lane)
Find max v/s
Find max v/s
1) C=[(1.5*L+5)/(1-sum(v/s))]
L= total lost time
2) g=[(v/s)/sum(v/s)]*(C-L)

Matlab script

```
clear
clc

%%  This program can be used to allocate green time to 2 phase a traffic signal
%   Input can be entered by a user, or in real time by road sensors
sa=input('Input the saturation flow rate for phase a: ');
vnr=input('Input the vehicular flow volume of northbound thru-right: ');
vnl=input('Input the vehicular flow volume of northbound thru-left: ');
vsr=input('input the vehicular flow volume of southbound thru-right: ');
vsl=input('Input the vehicular flow volume of southbound thru-left: ');
A=[vnr vnl vsr vsl];    % to find the critical lane for phase a
vacr=max(A);
sb=input('Input the saturation flow rate for phase b: ');
ve=input('Input the vehicular flow volume of eastbound thru-right-left: ');
vw=input('Input the vehicular flow volume of westbound thru-right-left: ');
B=[ve vw];  % to find the critical lane for phase b
vbcr=max(B);
L=8;    % total lost time is constant, but can be modified if necessary
%%  Functions are used to find the Cycle time and individual green times
[C,cr]= cycletime(L,sa,vacr,sb,vbcr);
ga= greenphase(L,C,cr,vacr,sa);
gb= greenphase(L,C,cr,vbcr,sb);
```

Matlab function 1

- function [C,cr] = cycletime(L,sa,vacr,sb,vbcr)
- % This function finds the total cycle time
- a= vacr/sa;
- b= vbcr/sb;
- cr= a+b;
- D= 1-cr;
- N= (1.5*L)+5;
- C= N/D;

- end

Matlab function 2

- function [gi] = greenphase(L,C,cr,vi,si)
- % This function finds the green time for each phase
- N= vi/si;
- M= N/cr;
- D= C-L;
- gi= M*D;

- end

Questions ?