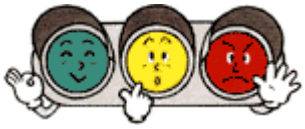
REPUBLIC OF UGANDA
MINISTRY OF WORKS AND TRANSPORT
(MOWT)

THE STUDY ON
GREATER KAMPALA
ROAD NETWORK AND
TRANSPORT IMPROVEMENT
IN THE REPUBLIC OF UGANDA

TRAFFIC SIGNAL OPERATION AND MAINTENANCE MANUAL



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JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

NIPPON KOEI CO., LTD.
EIGHT-JAPAN ENGINEERING CONSULTANTS INC.

TRAFFIC SIGNAL OPERATION AND MAINTENANCE MANUAL

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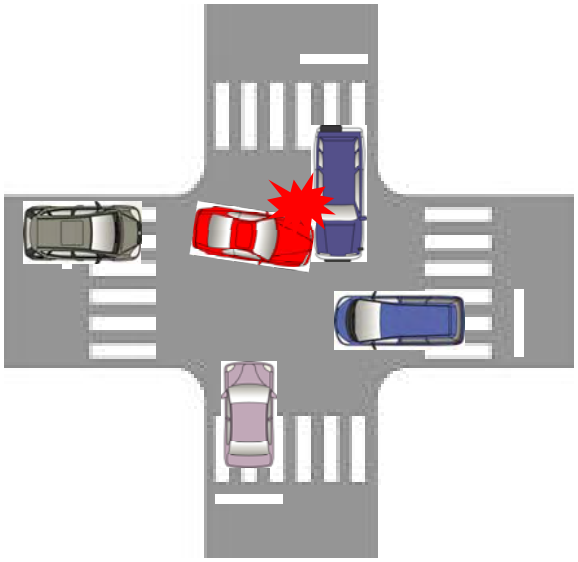
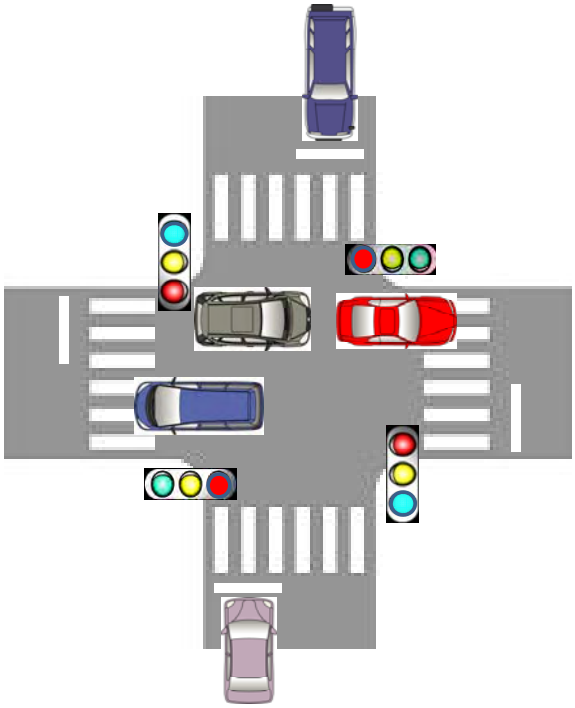
PART-1: PLANNING MANUAL

1-1. INTRODUCTION

At intersection, many vehicles flow into and intersect with each other, and also many pedestrians walk on a pedestrian crossing. Consequently, traffic flow including non-motorizes traffic becomes so complicated. Without a traffic signal control, a continuous flow of traffic on one roadway would cause excessive delay to vehicles and pedestrians waiting on the other. A traffic signal plays an important role to improve this situation.



A vehicle going straight should carefully pay attention to intersecting vehicles from left, right and opposite to find safe intervals. In case of low traffic volume, drivers can pass through intersection in a short time. But, at intersection with heavy traffic volume, drivers may be forced a long wait. In some case, quixotic behaviors course an accident and put lock on intersection.



And so, orderly traffic control by use of a traffic signal makes an effect on above situation. A traffic signal unlocks vehicles locked on intersection. Moreover, a vehicle going straight pays attention only to the opposite vehicles when signal light is green.

Sequence of green (go), yellow (prepare to stop) and red (stop) of a Traffic signal plays an important role for orderly control of vehicle flow.

1-2. THE ROLE OF TRAFFIC SIGNALS

(1) The Role Of Traffic Signals

- To prevent an accident

A traffic signal orderly controls various traffic flows by the sequence of signal lights to avoid traffic conflicts among vehicles and pedestrians.

- To make traffic flow smoothly

A traffic signal secures a smoother traffic flows by proper distribution of time responding to traffic volumes.

- To improve traffic environment

A Traffic signal accelerates smoother traffic flows and decelerates traffic pollutions such as CO2.

Advantage of Signals

A traffic signal that is properly located and operated is likely to:

- Provide for orderly movement of traffic;
- Increase traffic capacity of intersection;
- Reduce the frequency of certain types of crashes;
- Provide for continuous or nearly continuous movement of traffic along a given route; and
- Interrupt heavy traffic to permit other traffic, vehicular or pedestrian, to cross.

(2) Where And When Should A Signal Be Installed?

For aid the engineer in designing the appropriate control for intersection, the following 6 warrants are requirements of a traffic signal installation in Installation Standard for Traffic Signals (Japan).

- For vehicle traffic control
  - Both main roads and connected roads have a width of 10 m or more, and
  - Traffic volume in 12-hours is more than 7,000 vehicles, or
  - Traffic volume in peak-hour (1 hour) is more than 700 vehicles.
- For pedestrian control without intersection
  - Traffic volume in 12-hours is more than 6,000 vehicles, or
  - Traffic volume in peak-hour (1 hour) is more than 650 vehicles, and
  - Number of pedestrians who cross the road is more than 200 persons per hour.
- For prevention of an accident
  - In case that it is possible to prevent an accident by a traffic signal.

- For the school crossing and person with the visually impaired
- For the public facilities such as hospitals
- For bicycle control
    - Bicycle traffic volume in peak-hour (1 hour) is more than 700 vehicles, and
    - Traffic control by a traffic signal is required.

The engineers and/or responsible persons for traffic control should determine whether the traffic situation at intersection justifies considering a traffic signal.

(3) How Do You Grasp The Traffic Situation?

It is necessary for a traffic signal to orderly control traffic flow by grasping on-going traffic movement. It is important to know, "How many vehicles are running? Where are vehicles going? How fast are vehicles running? Where do traffic jams occur?" Also, quantity data is rather important than abstract data to correctly operate a traffic signal controller. The types of quantity data are explained as below.

Digitalization of Traffic Flow

The judgment of vacant situation and crowded situation on the road by the image is fuzzy. It is therefore traffic flow should be grasped as numerical data for proper operation of a traffic signal. Generally, following 3 traffic data are useful:

1) Traffic volume

Traffic volume means a number of vehicles passing through a certain point per unit time. The number of traffic volume normally increase with traffic volume increase on the road, but when traffic volume exceed road capacity, traffic volume is decreasing with traffic jam.

When a cycle time and phase for a traffic signal are decided and adjusted based on the actual demand, traffic volume and flow at intersection is the most important data. Hence, annual traffic survey is required for proper signal operation.

2) Travel speed

Travel speed means an average speed of vehicles passing through a certain point per unit time. Travel speed is getting down with traffic volume increase. In the traffic jam, travel speed becomes close to 0 km/h.

3) Traffic density

Traffic density means a number of vehicles existing in a certain section of road. Traffic density is getting higher with traffic volume increase. When vehicles stop by heavy traffic jam, traffic density reaches to maximum density.

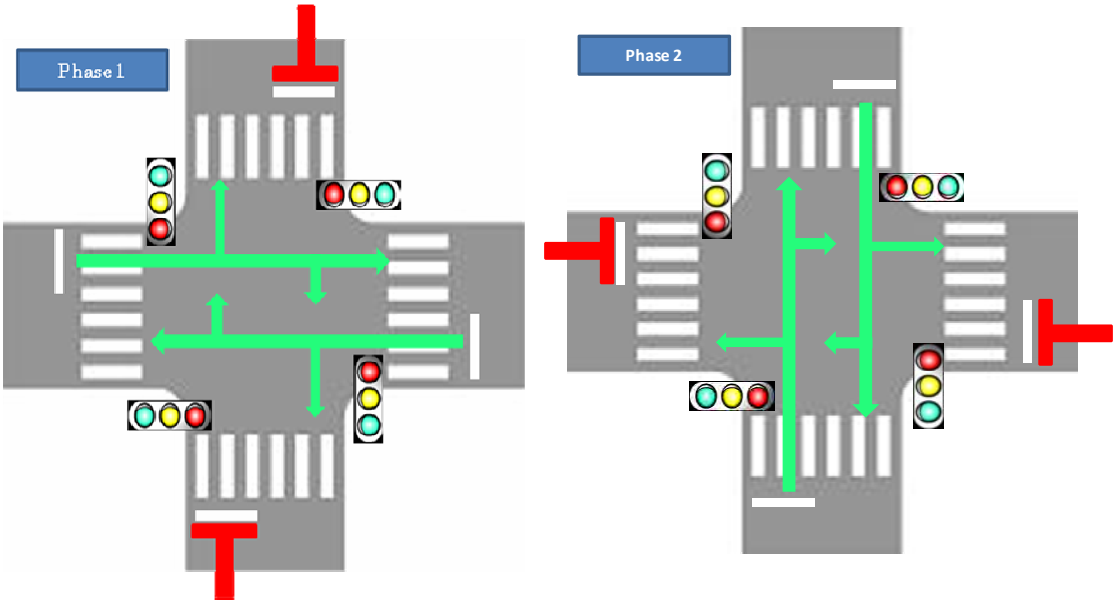
The situation of traffic flow can be defined by these 3 parameters. (Volume, Speed, Density)

1-3. PHASE OF TRAFFIC SIGNALS

(1) What Is Phase?

A traffic signal gives a passage right to vehicles which head for each direction by rotation. That is to say, only vehicles and pedestrians which get permission from a traffic signal can pass through the intersection. “Phase” is the time band given to vehicles and pedestrians for passing intersection.

At mid-level intersections, operation by 2-phase is the most commonly as following figure.



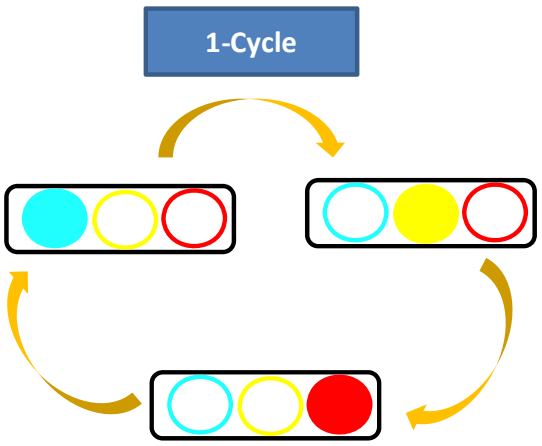
Where traffic volume of right-turning vehicles is dominated, a phase for right-turn is added. That case is called “3-phase operation”.

(2) Three Key Parameters For Traffic Signals

A signal flow consisting of Cycle, Sprit and Offset is the most important for proper signal operation.

- **Cycle**

“Cycle” means sequence of green (go), yellow (prepare to stop) and red (stop), and operates on the second time scale. In case of a short cycle, a traffic jam occurs because many vehicles cannot pass through intersection. The other way, in case of a long cycle, unnecessary time is created. A cycle should be decided in accordance with traffic volume, configuration of intersection and the number of the pedestrians. Generally, a cycle is proportionate to traffic volume.



However, a long cycle is not preferable from viewpoint of service level. Following cycle time is recommended by the Japanese Standard.

Definition of Service Level for Signalized Junctions

Service Level	Cycle Time (second)
A	70s and below
B	70s to 100s
C	100s and above

In case that a cycle time is operated with service level "C", a maximum cycle time should not be over 120s. Even if 120s and above is required by necessary, 180s is practical limit value. Frequently, a long cycle time generates to block straight traffic by queue for right-turn. Hence, to reduce a long queue for right-turning vehicles with a short cycle has a possibility of alleviation of a traffic jam at intersection.

- **Split**

"Split" means allocation time to each phase and operates in the percent (%). If split time is evenly allocated to all directions regardless of traffic volume, unnecessary time is created. Split should be allocated responding to traffic volume of each phase.

- **Offset**

"Offset" means the time lag between neighboring intersections for ensuring of smooth traffic on same road, and operates on the second time scale or percent per 1-cycle.

"Cycle", "Split" and "Offset" are key parameters to realize the smooth traffic control.

(3) What Is "Clearance Time"?

Clearance time is set for avoidance of a vehicle crash at the turning point of phases at intersection. When a traffic signal change from Phase-1 to Phase-2, vehicles that pass through intersection under Phase-1 should exactly stop at the stop line or certainly go out of intersection before stating of Phase-2. For this reason, Clearance time is set to clean out all vehicles on intersection, and is defined in total of time for yellow light and red light.

The length of clearance time finely set up responding to the size and configuration of intersection.

- **Yellow signal**

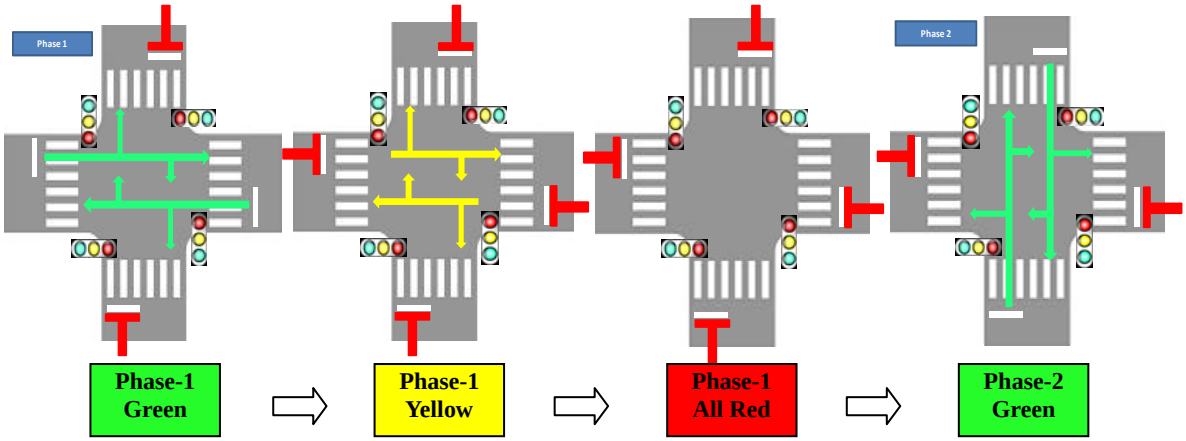
When a s change from green light to yellow right, some vehicles can stop at stop line. However some vehicles remain in intersection. Yellow light is provided to clean out all vehicles remained in intersection.

- **All red signal**

Time of all red is set up to clean out right-turning vehicles in intersection by starting of a next phase.

In case that the time length of yellow and all red signals is too long, some drivers may hardly wait until next phase or disregard yellow light. On the other hand, if the time length is too short, some vehicles are left out on intersection in a next phase starts. Hence, the length of clearance

time should be set appropriately.



In Japan, clearance time is normally provided as following table.

Clearance Time (Yellow + All Red): Second

Distance between Stop-line	20m			30m			40m			50m			60m		
Design Speed	Y	AR	T	Y	AR	T	Y	AR	T	Y	AR	T	Y	AR	T
30km/h	3	2	5	3	4	7	3	4	7	3	4	7	3	4	7
40km/h	3	2	5	3	3	6	3	4	7	3	4	7	3	4	7
50km/h	4	1	5	4	2	6	4	3	7	4	3	7	4	3	7
60km/h	4	1	5	4	2	6	4	2	6	4	3	7	4	3	7
70km/h	4	1	5	4	2	6	4	2	6	4	3	7	4	3	7
80km/h	4	1	5	4	2	6	4	2	6	4	3	7	4	3	7

Y: Yellow, AR: All Red, T: Total

(4) Time For Pedestrian Crossing

The time of "Green-light" and "Green-light blinking (winking)" of pedestrian signals are provided for safely pedestrian crossing.

- **Pedestrian green time**

The time of pedestrian green-light is finely derived based on the length of pedestrian crosswalk. Generally, walking speed is calculated as 1m to 1.5m/sec.

- **Green blinking (winking) time**

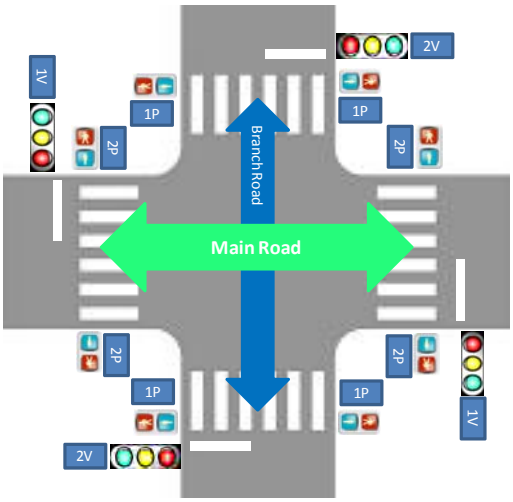
Green blinking (winking) is time for pedestrian judgment whether to go or back. Generally, it is set in 4 to 10 seconds.

If the pedestrian green time is too short, pedestrians cannot walk over to opposite side. On the other hand, the pedestrian green time is too long, vehicles turning to left and/or right may queue at intersection. Consequently, traffic jam is generated by pedestrian crossing. It is therefore the time of pedestrian crossing should be carefully set.

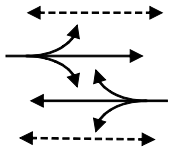
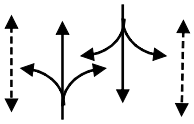
(5) Phase Of Traffic Signals

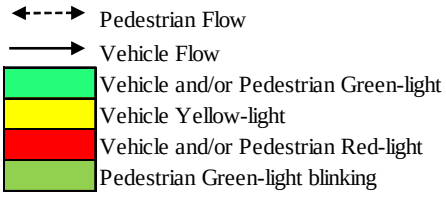
- **Standard phase: Two-phase operation**

When number of vehicles turning left or right is not so heavy, a phase for main road and branch road are alternately indicated. Usual signal layout at intersection is shown in right figure. “1V” and “2V” mean a traffic signal lights for vehicles, and “1P” and “2P” means a traffic signal lights for pedestrians. “1V and 1P” and “2V and 2P” are provided for the main road and branch road, respectively.



The time of signal indication change is called “Step”. The most major traffic control is “2 Phases / 10 Steps”. The following phase chart shows the step flow.

Step	1	2	3	4	5	6	7	8	9	10
1P										
1V										
2P										
2V										
Time (s)	45	5	5	3	2	25	5	5	3	2
Phase	1					2				
Flow										



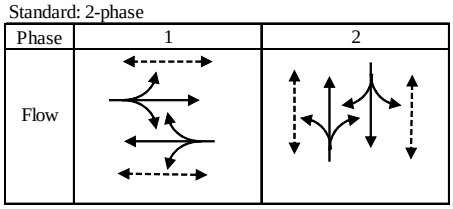
- **Phase for right-turning vehicles**

When right-turning vehicles are blocked by many through-vehicles, right-turning vehicles queue for right-turn in intersection. Consequently these right-turning vehicles may become congestible reason.

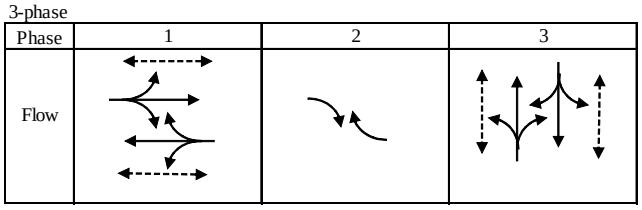
In this case, separation of through-vehicles and right-turning vehicles by a traffic signal is the most effective measure. In addition, a vehicle crash between right-turning vehicle and through-vehicle may be avoided.

For this reason, in case that many vehicles require turning right, separate phase for right-turn is added as following figures.

Standard: 2-phase



3-phase

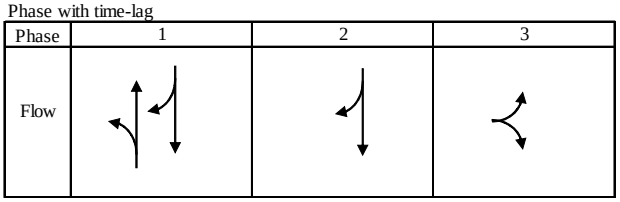


As just described, several phase types are proposed responding to traffic conditions and configurations as follows.

- **Phase with time-lag**

A phase with time-lag is that of two traffic flows under phase-1 (see figure below), green light for one flow is cut off earlier than another green light.

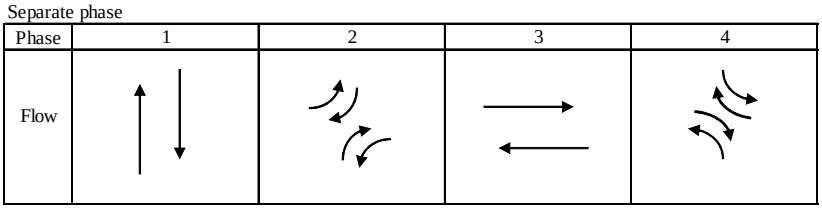
Phase with time-lag



- **Separate phase**

Instead of usual green lights, separate phase is controlled by green arrow signals composed of straight, right-turn and left-turn. Separate phase completely segregates turning-vehicles (right and/or left) and through-vehicles as following figure.

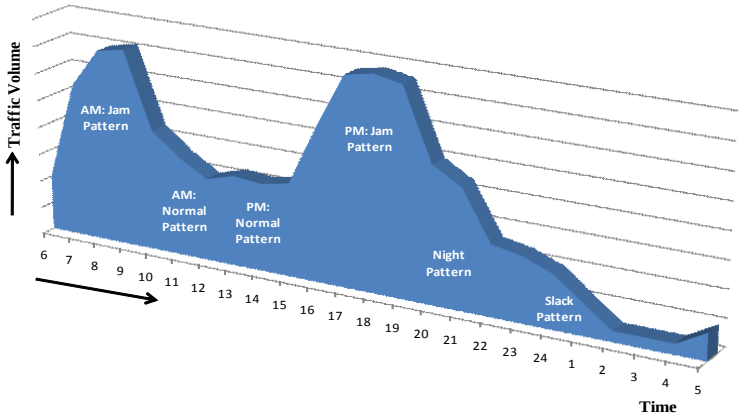
Separate phase



1-4. TYPE OF TRAFFIC SIGNAL CONTROL

(1) Independent Control (Multi-Pattern Control)

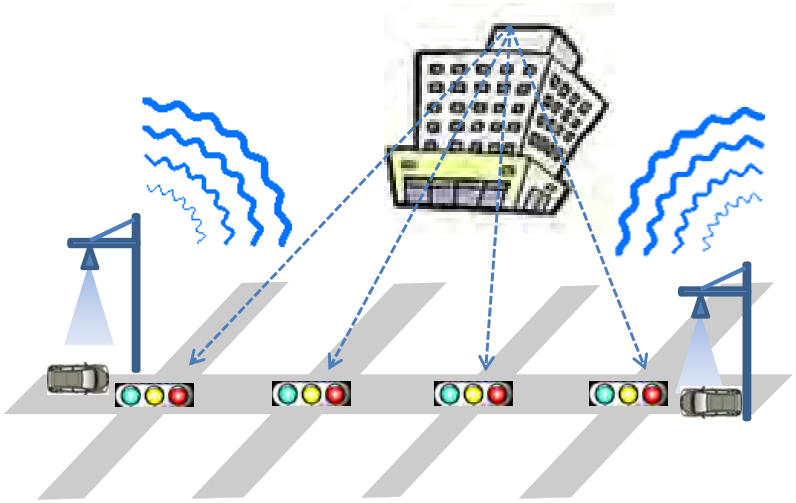
Traffic volume varies depending on time (morning, daytime, evening and night) and a day of week (see figure below). If a cycle time is never change, it may cause a traffic problem. Hence a cycle time is set in accordance with hourly and daily variation based on traffic volume and flow pattern obtained by traffic survey. This operation is called “multi-pattern control”. This operation is automatically controlled by electronic programmable timer in the signal controller.



(2) Coordinated (Lined) Control

What does it happened if traffic signals on the same road are independently operated regardless of the neighboring traffic signals? The vehicles might be forced to stop at every intersection. In the result, discontinuous operation may bring traffic jams and/or a lot of wasted time. Coordinated (lined) control which links continuing signals is alleviates this situation.

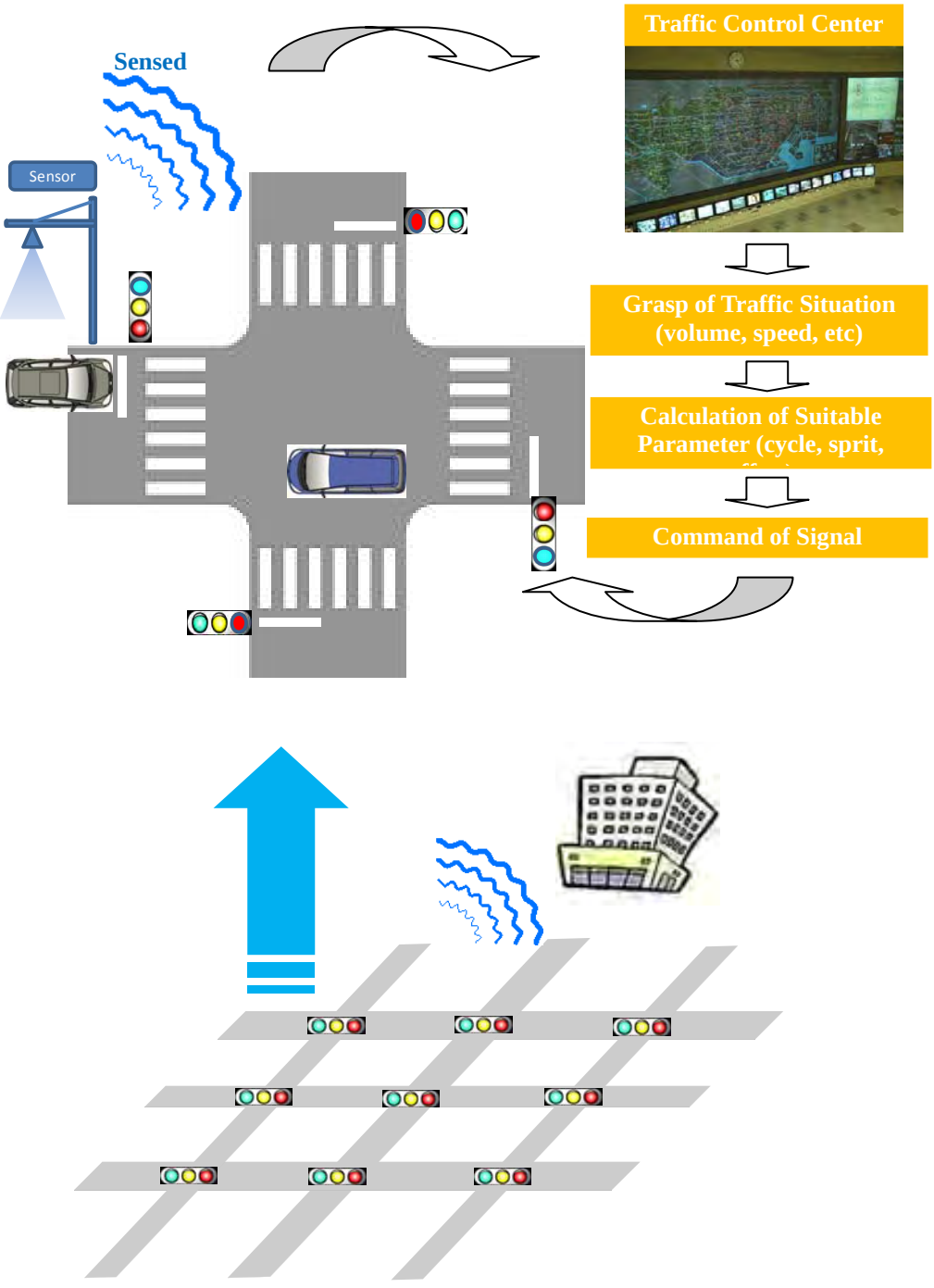
Traffic signals under coordinated control should be operated in the same cycle time, and linked by offset time.



(3) Area Control (Wide Area Control)

At the major cities, many roads composed of trunk roads, branch roads and/or streets lie in the city and a lot of traffic signals are installed due to the control of traffic flow and prevention of an accident. What does it happened if traffic signals in the same area are independently operated? The traffic would be thrown into a terrible confusion. Even if this situation is controlled by use of the coordinated control for trunk roads, traffic conditions on branch roads and streets would not improved. Hence, area control is required in such situation. Area control is unified management by "Traffic Control Center".

- **Image of Area Control**



1-5. CASE STUDY (COMPENDIUM METHOD)

(1) Setting Of Cycle Time Base On The Traffic Volume

This method easily derives suitable time for each phase based on the traffic volume data.

1) Setting of Clearance Time and etc

1: Time of All Red: 2 s (G, L)

2: Time of Yellow: 3 s (D, F, K)

3: Time of Blinking for Pedestrian:

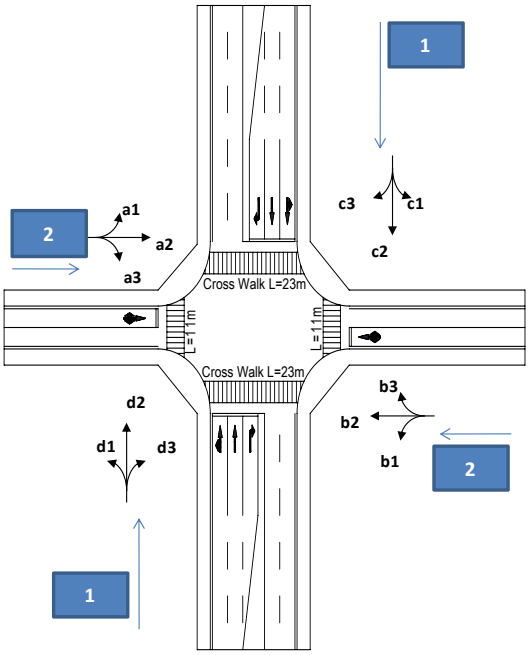
Half of Cross Walk Length is divided by 1.5m (Walker's speed)

In case of right figure

11.0m/2/1.5m = 3.7s (B)

23.0m/2/1.5m = 7.7s (I)

4: Time of Green for Vehicles and Red for Pedestrians: 3s (C, J)



2) Calculation of Traffic Volume for each Lane

Considerable lane number for design should apply the lane number of inflow side of intersection.

Case of Light No.1:

1st (left) lane: for left-turn + through

2nd (middle) lane: for through

3rd (right) lane: for right-turn

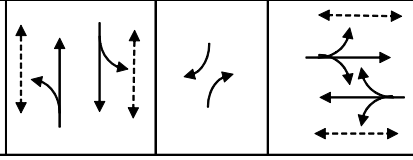
Traffic Volume (vehicle/peak hour)

1st lane: (c1+c2)/2

2nd lane: c2-((c1+c2)/2-c1)

3rd lane: c3

Ditto calculation is repeated about d1, d2 and d3.

Light No.	Step	1	2	3	4	5	6	7	8	9	10	11	12
1	1P												
	1V												
	1A												
2	2P												
	2V												
Time (s)		x	3.7	3	3	x	3	2	x	7.7	3	3	2
		A	B	C	D	E	F	G	H	I	J	K	L
Cycle		Select from (80,100,120,140,160,180)s											
Phase		1				2			3				
Flow													

Vehicle and/or Pedestrian Green-light
Vehicle Yellow-light
Vehicle and/or Pedestrian Red-light
Pedestrian Green-light blinking

Case of Light No.2

One lane: for all directions

Traffic Volume (vehicle/peak hour)

One lane: a1+a2+a3

Ditto calculation is repeated about b1, b2 and b3.

3) Calculation of Sprit Time

Sprit time (allocation time to each phase) is distributed responding to traffic volume calculated above step. Specifically, maximum traffic volume for phase-1 is picked from among 1st lane and 2nd lane of both sides. Then maximum traffic volumes for phase-2 and phase-3 are also picked from among calculated traffic volume, respectively.

Next, a cycle time is selected from among (80s, 100s, 120s, 140s, 160s, and 180s) in consideration of traffic volume. As described in sub-chapter I-3. (2), a cycle time that 120s is not preferable unless absolutely necessary. In addition, in case of low traffic volume (e.g. midnight), a short cycle time is efficient.

4) Calculation of Green Time

Green time is derived from sprit time 3) and other required time 1).

3): sprit time – 1): clearance time, etc = Green time.

(2) Case Study (Jinja Jct. and Kibuli Jct.)

Before stating of case studies, evaluation method has to decide. A signalized junction is normally evaluated as follows by use of saturation degree.

Evaluation of Signalized Junction by Saturation Degree

Saturation Degree	Situation
$0.8 > S$	Desirable Situation
$0.8 \leq S \leq 1.0$	Acceptable Situation
$1.0 < S$	Capacity Shortage (Bottleneck)

However, calculation of saturation degree is required a lot of information, additionally, calculation steps is so complicated. Hence, in this case study, congestion degree is applied. Here are necessary factors for evaluation by congestion degree:

1) Basic Capacity of Each Type of Lane

Trough Lane: 2,000 p.c.u./lane/hour (p.c.u.: passenger car unit)

Left-Turn and Right-Turn Lane: 1,800 p.c.u./lane/hour

Left-Turn + Through Lane: 2,000 p.c.u./lane/hour

Trough + Right-Turn Lane: 2,000 p.c.u./lane/hour

2) Adjustment Factor for Lane Width

2.5m to 3.0m: 0.95

3.0m and above: 1.00

3) Adjustment Factor for Approach Gradient

Gradient (%)	Adjustment Factor	Gradient (%)	Adjustment Factor
-6	0.95	1	1.00
-5	0.96	2	0.95
-4	0.97	3	0.90
-3	0.98	4	0.85
-2	0.99	5	0.80
-1	1.00	6	0.75
0	1.00		

4) Adjustment Factor for Heavy Vehicles (Ratio of Heavy Vehicles: %)

Ratio (%)	Adjustment Factor	Ratio (%)	Adjustment Factor
0	1.00	55	0.72
5	0.97	60	0.70
10	0.93	65	0.69
15	0.90	70	0.67
20	0.88	75	0.66
25	0.85	80	0.64
30	0.83	85	0.63
35	0.80	90	0.61
40	0.78	95	0.60
45	0.76	100	0.59
50	0.74		

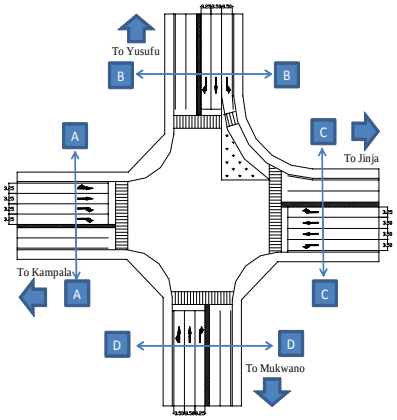
5) Adjustment Factor for Left-Turning and Right-Turning Vehicles and Pedestrians

Calculation for these factors is so complicated. Hence, in this compendium method, these factors are not applied.

6) Result of Case Study for Jinja Junction

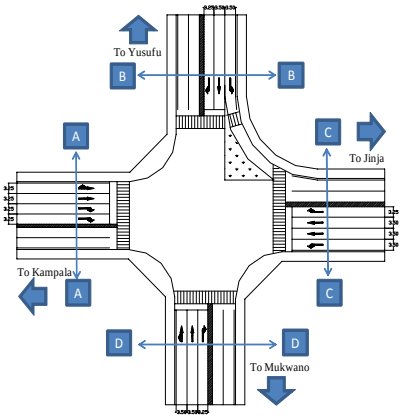
Peak Hour: 8 am to 9 am

Approach		A from Kampala Rd			B from Yusufu Lule Rd			C from Jinja Rd			D from Mukwano Rd		
		LT+TR	TR	RT	LT	TR	RT	LT	TR	RT	LT+TR	TR	RT
Number of Lane		1	1	2	1	1	1	1	2	1	1	1	1
Capacity / Lane /Hour		2000	2000	1800	1800	2000	1800	1800	2000	1800	2000	2000	1800
Adjustment Factor		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
(Lane width: m)		3.25	3.25	3.25	3.5	3.5	3.25	3.5	3.5	3.25	3.5	3.5	3.25
Adjustment Factor		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
(Gradient: %)		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adjustment Factor		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
(Share of large vehicle: %)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Adjustment Factor (Left Turn)		N/A	-	-	-	-	-	-	-	-	N/A	-	-
Adjustment Factor (Right Turn)		-	-	-	-	-	-	-	-	-	-	-	-
Calculated Capacity /Lane /Hour		2000	2000	3600	1800	2000	1800	1800	4000	1800	2000	2000	1800
Traffic volume (pcu/hr)		394	458	403	561	356	228	289	2246	308	453	524	277
(Left turn or Right turn)		9	-	403	561	-	228	289	-	308	86	-	277
Current cycle length: sec		249											
Current green time: sec	phase-1	84.00	84.00	-	-	-	-	84.00	84.00	-	-	-	-
	phase-2	-	-	50.00	-	-	-	-	-	50.00	-	-	-
	phase-3	-	-	-	-	48.00	-	-	-	-	48.00	48.00	-
	phase-4	-	-	-	-	-	43.00	-	-	-	-	-	43.00
Actual Current Capacity		675	675	723	1800	386	311	607	1349	361	386	386	311
Cureent Congestion degree		0.58	0.68	0.56	0.31	0.92	0.73	0.48	1.66	0.85	1.18	1.36	0.89
Cureent Congestion degree at whole JCT		0.82											
Select cycle length: sec		180											
Proposed green time: sec	phase-1	63.00	63.00	-	-	-	-	63.00	63.00	-	-	-	-
	phase-2	-	-	21.00	-	-	-	-	-	21.00	-	-	-
	phase-3	-	-	-	-	56.00	-	-	-	-	56.00	56.00	-
	phase-4	-	-	-	-	-	24.00	-	-	-	-	-	24.00
Actual Capacity by proposal		700	700	420	1800	622	240	630	1400	210	622	622	240
Congestion degree		0.56	0.65	0.96	0.31	0.57	0.95	0.46	1.60	1.46	0.73	0.84	1.15
Congestion degree at whole JCT		0.79											



Peak Hour: 5 pm to 6 pm

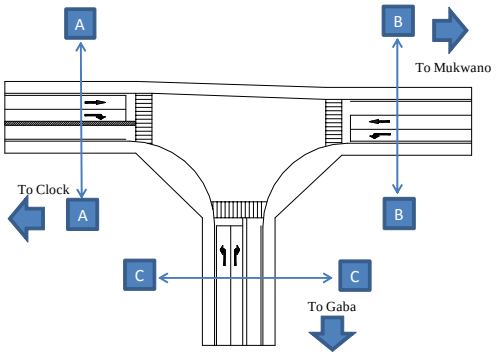
Approach		A from Kampala Rd			B from Yusufu Lule Rd			C from Jinja Rd			D from Mukwano Rd		
		LT+TR	TR	RT	LT	TR	RT	LT	TR	RT	LT+TR	TR	RT
Number of Lane		1	1	2	1	1	1	1	2	1	1	1	1
Capacity / Lane /Hour		2000	2000	1800	1800	2000	1800	1800	2000	1800	2000	2000	1800
Adjustment Factor		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
(Lane width: m)		3.25	3.25	3.25	3.5	3.5	3.25	3.5	3.5	3.25	3.5	3.5	3.25
Adjustment Factor		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
(Gradient: %)		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adjustment Factor		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
(Share of large vehicle: %)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Adjustment Factor (Left Turn)		N/A	-	-	-	-	-	-	-	-	N/A	-	-
Adjustment Factor (Right Turn)		-	-	-	-	-	-	-	-	-	-	-	-
Calculated Capacity /Lane /Hour		2000	2000	3600	1800	2000	1800	1777	4000	1800	2000	2000	1800
Traffic volume (pcu/hr)		478	555	837	1507	45	0	275	1501	193	432	498	443
(Left turn or Right turn)		8	-	837	1507	-	0	275	-	193	103	-	443
Current cycle length: sec		239											
Current green time: sec	phase-1	61.00	61.00	-	-	-	-	61.00	61.00	-	-	-	-
	phase-2	-	-	34.00	-	-	-	-	-	34.00	-	-	-
	phase-3	-	-	-	-	43.00	-	-	-	-	43.00	43.00	-
	phase-4	-	-	-	-	-	73.00	-	-	-	-	-	73.00
Actual Current Capacity		510	510	512	1800	360	550	454	1021	256	360	360	550
Congestion degree		0.94	1.09	1.63	0.84	0.13	0.00	0.61	1.47	0.75	1.20	1.38	0.81
Cureent Congestion degree at whole JCT		0.93											
Select cycle length: sec		180											
Proposed green time: sec	phase-1	63.00	63.00	-	-	-	-	63.00	63.00	-	-	-	-
	phase-2	-	-	27.00	-	-	-	-	-	27.00	-	-	-
	phase-3	-	-	-	-	34.00	-	-	-	-	34.00	34.00	-
	phase-4	-	-	-	-	-	40.00	-	-	-	-	-	40.00
Actual Capacity by proposal		700	700	540	1800	378	400	622	1400	270	378	378	400
Congestion degree		0.68	0.79	1.55	0.84	0.12	0.00	0.44	1.07	0.71	1.14	1.32	1.11
Congestion degree at whole JCT		0.85											



Note: Traffic volume surveyed by the Study Team is applied. (January, 2010)
Red letters show proposed allocation time by the Study Team
Yellow cells show that there is an improvement effect.

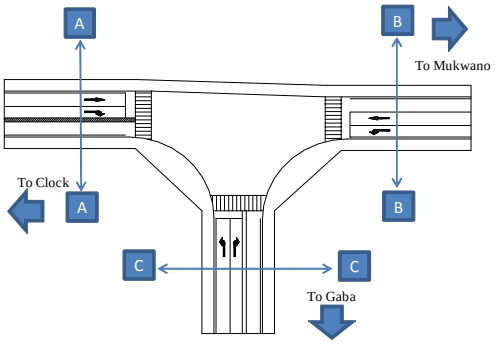
Peak Hour: 8 am to 9 am

Approach		A from Clock		B from Mukwano		C from Gaba	
		TR	RT	LT	TR	LT	RT
Number of Lane		1	1	1	1	1	1
Capacity / Lane /Hour		2000	1800	1800	2000	1800	1800
Adjustment Factor		1.00	1.00	1.00	1.00	1.00	1.00
(Lane width: m)		3.50	3.50	3.50	3.50	3.50	3.50
Adjustment Factor		1.00	1.00	1.00	1.00	1.00	1.00
(Gradient: %)		1.00	1.00	1.00	1.00	1.00	1.00
Adjustment Factor		1.00	1.00	1.00	1.00	1.00	1.00
(Share of large vehicle: %)		0.00	0.00	0.00	0.00	0.00	0.00
Adjustment Factor (Left Turn)		-	-	-	-	-	-
Adjustment Factor (Right Turn)		-	-	-	-	-	-
Calculated Capacity /Lane /Hour		2000	1800	1800	2000	1800	1800
Traffic volume (pcu/hr)		338	630	214	686	1,407	88
(Left turn or Right turn)		-	630	214	-	1,407	88
Current cycle length: sec		120					
Current green time: sec	phase-1	33.00	-	33.00	33.00	-	-
	phase-2	-	53.00	-	-	53.00	-
	phase-3	-	-	-	16.00	-	16.00
Actual Current Capacity		550	795	495	817	795	240
Congestion degree		0.61	0.79	0.43	0.84	1.77	0.37
Cureent Congestion degree at whole JCT		0.911					
Select cycle length: sec		120					
Proposed green time: sec	phase-1	31.00	-	31.00	31.00	-	-
	phase-2	-	63.00	-	-	63.00	-
	phase-3	-	-	-	11.00	-	11.00
Actual Capacity by proposal		517	945	465	700	945	165
Congestion degree		0.65	0.67	0.46	0.98	1.49	0.53
Congestion degree at whole JCT		0.900					



Peak Hour: 4 pm to 5 pm

Approach		A from Clock		B from Mukwano		C from Gaba	
		TR	RT	LT	TR	LT	RT
Number of Lane		1	1	1	1	1	1
Capacity / Lane /Hour		2000	1800	1800	2000	1800	1800
Adjustment Factor		1.00	1.00	1.00	1.00	1.00	1.00
(Lane width: m)		3.50	3.50	3.50	3.50	3.50	3.50
Adjustment Factor		1.00	1.00	1.00	1.00	1.00	1.00
(Gradient: %)		1.00	1.00	1.00	1.00	1.00	1.00
Adjustment Factor		1.00	1.00	1.00	1.00	1.00	1.00
(Share of large vehicle: %)		0.00	0.00	0.00	0.00	0.00	0.00
Adjustment Factor (Left Turn)		-	-	-	-	-	-
Adjustment Factor (Right Turn)		-	-	-	-	-	-
Calculated Capacity /Lane /Hour		2000	1800	1800	2000	1800	1800
Traffic volume (pcu/hr)		536	535	226	686	878	186
(Left turn or Right turn)		-	535	226	-	878	186
Current cycle length: sec		120					
Current green time: sec	phase-1	33.00	-	33.00	33.00	-	-
	phase-2	-	53.00	-	-	53.00	-
	phase-3	-	-	-	16.00	-	16.00
Actual Current Capacity		550	795	495	817	795	240
Congestion degree		0.97	0.67	0.46	0.84	1.10	0.77
Cureent Congestion degree at whole JCT		0.825					
Select cycle length: sec		120					
Proposed green time: sec	phase-1	41.00	-	41.00	41.00	-	-
	phase-2	-	53.00	-	-	53.00	-
	phase-3	-	-	-	11.00	-	11.00
Actual Capacity by proposal		683	795	615	867	795	165
Congestion degree		0.78	0.67	0.37	0.79	1.10	1.13
Congestion degree at whole JCT		0.777					



Note: Traffic volume surveyed by the Study Team is applied. (Jun, 2010)
Red letters show proposed allocation time by the Study Team
Yellow cells show that there is an improvement effect.

Note that traffic volume of both junctions is already converted to volume of passenger car unit. Hence, adjustment factor for large vehicle is not considered. Conversion factor from large vehicle to passenger car is normally decided between 2.0 to 3.0.

7) How to Derive Congestion Degree (e.g. TR lane of Section A at Kibuli Jct.: PM peak data)

Capacity/lane/hour = 2,000 p.c.u./lane/hour

Every adjustment factors (lane width, grade and share of large vehicle) are 1.0

Adjustment factors for right-turning vehicles, left-turning vehicles and pedestrians are not applied in this compendium method.

Hence:

Calculated Capacity/lane/hour = 2,000 x 1.0 x 1.0 x 1.0 =2,000 p.c.u/lane/hour

Next, allocated time for TR lane of section A should be considered. Its time is 41s, and a cycle time is 120s. It is therefore:

Actual capacity/lane/hour = 2,000 p.c.u. x 41s/120s = 683 p.c.u./lane/hour

Finally, ratio of traffic volume (p.c.u./lane/hour) and actual capacity (p.c.u./lane/hour) is the congestion degree.

Congestion degree = 536/683 = 0.78

Congestion degree of whole junction is derived from ratio of total traffic volume and total actual capacity.

Congestion degree at whole junction =

(536+535+226+686+878+186)/(683+795+615+867+795+165) = 0.78

PART-2: PERIODIC MAINTENANCE MANUAL

Periodic maintenance should be carried out with necessary interval specified in the "Check Sheets". When failures are found by inspections, those facilities should be repaired or changed as soon as possible. That work progress should be recorded in "Working Sheets".

2-1. MAINTENANCE FOR TRAFFIC SIGNALS

(1) Inspection for Distribution Board

- Check of main unit of distribution board. When some damages such as blemishes and/or rusts are found, those damages should be repaired:

  Blemishes: repainting

  Rusts: rub off the rust and repainting

- Cleaning of outside and/or inside of distribution board

  Be careful not to touch the switch and/or terminal

- Check of slacks of attaching screws and/or bolts. When slacks are found, those should be retightened.

  Be careful not to tighten with excessive power

- Check of slacks and/or coming off of wirings. When slacks and/or coming off are found, those should be reconnected.

  Be careful not to make wiring short out

- Check of coatings of wirings. When some damages are found, those should be recoated with insulating tapes.

- Measure of input voltage of commercial power supply

  Be careful not to make wiring short out

(2) Inspection for Controller

- Check of controller. When some damages such as blemishes and/or rusts are found, those damages should be repaired:

  Blemishes: repainting

  Rusts: rub off the rust and repainting

- Cleaning of outside and/or inside of controller

  Be careful not to touch the switch and/or terminal

- Check of slacks of attaching screws and/or bolts. When slacks are found, those should be retightened.

  Be careful not to tighten with excessive power

- Check of slacks and/or coming off of wirings. When slacks and/or coming off are found,

those should be reconnected.

Be careful not to make wiring short out

- Check of coatings of wirings. When some damages are found, those should be recoated with insulating tapes.
- Check of date and clock time. When date and clock time are not matched, those should be re-coordinated.
- Measure of voltage of power input unit
- Measure of voltage of power output unit to traffic signal
- Measure of voltage of controller power section

(3) Inspection for Traffic Signals

- Check of traffic signal. When some damages such as blemishes, rusts and/or gaps are found, those damages should be repaired:

  Blemishes: repainting

  Rusts: rub off the rust and repainting

  Gaps: fill a gap by use of tapes and/or putties

- Cleaning of outside and/or inside of traffic signal and lenses

  Be careful not to touch the switch and/or terminal

- Check of slacks of attaching screws and/or bolts. When slacks are found, those should be retightened.

  Be careful not to tighten with excessive power

- Check of slacks and/or coming off of wirings. When slacks and/or coming off are found, those should be reconnected.

  Be careful not to make wiring short out

- Check of coatings of wirings. When some damages are found, those should be recoated with insulating tapes.
- Check of visibility of signals at predefined position. When visibilities are not appropriate, traffic signals should be turned around.

  Signal for vehicles: to be viewable form stop line and 30m before stop line

  Signal for pedestrians: to viewable from center of zebra crossing and stopping position

- Check of lighting

  Bulb type: When light bulbs are burned out, those should be changed promptly.

LED type: When some LEDs are burned out and visibility is not appropriate, LED unit should be changed.

(4) Inspection for Signal Poles

- Check of signal poles. When some damages such as blemishes, rusts, gaps, tilts and/or bentnesses are found, those damages should be repaired:

  Blemishes: repainting

  Rusts: rub off the rust and repainting

  Gaps: record of the degree and reinforcement or re-built where necessary

  Tilts and bentnesses: record of the degree and reinforcement or re-built where necessary

- Check of base of poles. When some damages such as cracks and/or bumps are found, those damages should be reinforced.

- Cleaning and removal of posters and/or advertising displays.

(5) Inspection for Hand-hole

- Check of cover of hand-holes. When some damages such as cracks and/or breakings are found, those damages should be repaired or changed.

- Check of inside of catch pits. When some damages such as cracks and/or breakings are found, those damages should be reinforced with cements or mortar. In addition, when water and/or solid refuses are found inside catch pit, those should be removed.

- Check of signal cables inside catch pits. When damages are found, those should be recoated with insulating tapes.

- After cleaning of frame for covers, close the cover steady.

2-2. MAINTENANCE FOR POWER SUPPLY UNITS

(1) Refuel to AEG (Automatic Engine Generator)

- Refuel to AEG should be done before getting empty. Work day and refuel volume should be recorded.
- Accumulation running time should be recorded.
- Check of error display on operation panel. When error display is indicated on operation panel, it should be reset in accordance with the operation manual.
- Check of fuel leakage. When fuel leakage is found, it should be repaired and cleaned.
- After making AEG run, noises, unusual odors and/or unusual vibrations should be checked.

(2) Inspection of AEG (Automatic Engine Generator)

- Check of AEG body. When some damages such as blemishes and/or rusts are found, those damages should be repaired:

  Blemishes: repainting

  Rusts: rub off the rust and repainting
- Check of oil leakage. When oil leakage is found, it should be repaired and cleaned.
- Change of engine oil. Used amount of oil should be recorded.
- Cleaning of oil filter. When pollution of oil filter does not clean off, oil filter should be changed.

  Be careful not to pollute oil filter.
- Cleaning of fuel filter. When pollution of fuel filter does not clean off, fuel filter should be changed.

  Be careful not to pollute fuel filter.
- Drain from fuel tank.
- Cleaning of air cleaner. When pollution of air cleaner does not clean off, air cleaner should be changed.

  Be careful not to pollute air cleaner.
- Cleaning of inside and outside of AEG, and intake air filter

  Be careful not to touch the switch and/or terminal
- Check of slacks of attaching screws and/or bolts. When slacks are found, those should be retightened.

  Be careful not to tighten with excessive power

- Check of slacks and/or coming off of wirings. When slacks and/or coming off are found, those should be reconnected.

  Be careful not to make wiring short out

- Check of coatings of wirings. When some damages are found, those should be recoated with insulating tapes.

- Check of date and clock time of AEG. When date and clock time are not matched, those should be re-coordinated.

- Measure of output voltage

- Measure of output current

(3) Inspection of AVR (Automatic Voltage Regulator)

- Cleaning of AVG

  Be careful not to touch the switch and/or terminal

- Check of slacks and/or coming off of wirings. When slacks and/or coming off are found, those should be reconnected.

  Be careful not to make wiring short out

- Check of coatings of wirings. When some damages are found, those should be recoated with insulating tapes.

- Measure of input voltage

- Measure of input current

- Measure of output voltage

- Measure of output current

(4) Inspection of UPS (Uninterruptible Power System)

- Cleaning of intake duct after opening of main body and/or front panel.

  Be careful not to touch the switch and/or terminal

- Check of slacks and/or coming off of wirings. When slacks and/or coming off are found, those should be reconnected.

  Be careful not to make wiring short out

- Check of coatings of wirings. When some damages are found, those should be recoated with insulating tapes.

- Check of exchange time of battery. After pressing the self- test button, if low battery service mark is illustrated, the battery may need replacing.

2-3. CHECK SHEETS FOR EACH INSPECTION

The check sheets for each inspection are attached in this sub-chapter for efficient and effective maintenance works. The inspector should take these check sheets to the site and record at site.

After finishing of inspection works, responsible person should check and file these records.

Component of check sheets is as follows:

- TRAFFIC SIGNAL SYSTEM: Distribution Panel / Traffic Signal Controller
- TRAFFIC SIGNAL SYSTEM: Traffic Signal Light for Vehicle GYR
- TRAFFIC SIGNAL SYSTEM: Traffic Signal Light for Vehicle 3 Arrows
- TRAFFIC SIGNAL SYSTEM: Traffic Signal Light for Vehicle 1 Arrow
- TRAFFIC SIGNAL SYSTEM: Traffic Signal Light for Pedestrian
- TRAFFIC SIGNAL SYSTEM: Signal Pole
- TRAFFIC SIGNAL SYSTEM: Hand-hole
- POWER BACK UP SYSTEM: Automatic Engine Generator / Automatic Voltage Regulator / Uninterruptible Power System
- AUTOMATIC ENGINE GENERATOR: REFUEL SHEET
- WORK RECORD SHEET
- MAINTENANCE TOOLS / INSTRUMENTS
- SPARE PARTS LIST

TRAFFIC SIGNAL SYSTEM MAINTENANCE CHECK SHEET

(Distribution Panel / Traffic Signal Controller)

Junction : _____

Need to maintenance : Every 6 Months

Date : / /

Equipment	Item	Result		Remarks
Distribution Panel	Damages of body (flaw, rust, etc.)	☐ OK	☐ NG	
	Cleaning outside / inside	☐ DONE		
	Tightening of bolts / screws	☐ OK	☐ NG	
	Connection of wires / terminals	☐ OK	☐ NG	
	Damages of cables/ wires coating	☐ OK	☐ NG	
	Measurement of commercial power input	V		
Traffic Signal Controller	Damages of body (flaw, rust, etc.)	☐ OK	☐ NG	
	Cleaning outside / inside	☐ DONE		
	Tightening of bolts / screws	☐ OK	☐ NG	
	Connection of wires / terminals	☐ OK	☐ NG	
	Damages of cables/ wires coating	☐ OK	☐ NG	
	Value of time / date	☐ OK	☐ RESET	
	Measurement of power input	V		
	Measurement of traffic light output	V		
	Measurement of control power output	V		

TRAFFIC SIGNAL SYSTEM MAINTENANCE CHECK SHEET

(Traffic Signal Light for Vehicle GYR)

Need to maintenance : Every 6 Months

Junction : _____ ☐Bulb ☐LED Date : / /

No. of Lights	Damages of body (flaw, rust, etc.)	Cleaning outside / lens	Tightening of bolts / screws	Connection of wires / terminals	Damages of cables / wires coating	Direction of traffic light	Light condition G	Light condition Y	Light condition R	Remarks
1	☐OK ☐NG	☐DONE	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	
2	☐OK ☐NG	☐DONE	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	
3	☐OK ☐NG	☐DONE	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	
4	☐OK ☐NG	☐DONE	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	
5	☐OK ☐NG	☐DONE	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	
6	☐OK ☐NG	☐DONE	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	
7	☐OK ☐NG	☐DONE	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	
8	☐OK ☐NG	☐DONE	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	

TRAFFIC SIGNAL SYSTEM MAINTENANCE CHECK SHEET

(Traffic Signal Light for Vehicle 3 Arrows)

Junction : _____

☐Bulb ☐LED

Need to maintenance : Every 6 Months

Date : / /

No. of Lights	Damages of body (flaw, rust, etc.)	Cleaning outside / lens	Tightening of bolts / screws	Connection of wires / terminals	Damages of cables / wires coating	Direction of traffic light	Light condition Left	Light condition Straight	Light condition Right	Remarks
1	☐OK ☐NG	☐ DONE	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	
2	☐OK ☐NG	☐ DONE	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	
3	☐OK ☐NG	☐ DONE	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	
4	☐OK ☐NG	☐ DONE	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	
5	☐OK ☐NG	☐ DONE	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	
6	☐OK ☐NG	☐ DONE	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	
7	☐OK ☐NG	☐ DONE	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	
8	☐OK ☐NG	☐ DONE	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	

TRAFFIC SIGNAL SYSTEM MAINTENANCE CHECK SHEET

(Traffic Signal Light for Vehicle 1 Arrow)

Junction : _____

☐Bulb ☐LED

Need to maintenance : Every 6 Months

Date : / /

No. of Lights	Damages of body (flaw, rust, etc.)	Cleaning outside / lens	Tightening of bolts / screws	Connection of wires / terminals	Damages of cables / wires coating	Direction of traffic light	Light condition	Remarks
1	☐OK ☐NG	☐ DONE	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	
2	☐OK ☐NG	☐ DONE	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	
3	☐OK ☐NG	☐ DONE	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	
4	☐OK ☐NG	☐ DONE	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	
5	☐OK ☐NG	☐ DONE	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	
6	☐OK ☐NG	☐ DONE	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	
7	☐OK ☐NG	☐ DONE	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	
8	☐OK ☐NG	☐ DONE	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	

TRAFFIC SIGNAL SYSTEM MAINTENANCE CHECK SHEET

(Traffic Signal Light for Pedestrian)

Junction : _____

☐Bulb ☐LED

Need to maintenance : Every 6 Months

Date : / /

No. of Lights	Damages of body (flaw, rust, etc.)	Cleaning outside / lens	Tightening of bolts / screws	Connection of wires / terminals	Damages of cables / wires coating	Direction of traffic light	Light condition G	Light condition R	Remarks
1	☐OK ☐NG	☐ DONE	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	
2	☐OK ☐NG	☐ DONE	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	
3	☐OK ☐NG	☐ DONE	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	
4	☐OK ☐NG	☐ DONE	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	
5	☐OK ☐NG	☐ DONE	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	
6	☐OK ☐NG	☐ DONE	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	
7	☐OK ☐NG	☐ DONE	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	
8	☐OK ☐NG	☐ DONE	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	☐OK ☐NG	

TRAFFIC SIGNAL SYSTEM MAINTENANCE CHECK SHEET

(Signal Pole)

Junction : _____

Need to maintenance : Every 6 Months

Date : / /

No. of Poles	Check of growing hole	Check of inclination / bend	Damages of body (flaw, rust, etc.)	Damages of root / footing	Cleaning	Remarks
1	☐NO ☐YES (Size:)	☐NO ☐YES (Degree:)	☐OK ☐NG	☐OK ☐NG	☐ DONE	
2	☐NO ☐YES (Size:)	☐NO ☐YES (Degree:)	☐OK ☐NG	☐OK ☐NG	☐ DONE	
3	☐NO ☐YES (Size:)	☐NO ☐YES (Degree:)	☐OK ☐NG	☐OK ☐NG	☐ DONE	
4	☐NO ☐YES (Size:)	☐NO ☐YES (Degree:)	☐OK ☐NG	☐OK ☐NG	☐ DONE	
5	☐NO ☐YES (Size:)	☐NO ☐YES (Degree:)	☐OK ☐NG	☐OK ☐NG	☐ DONE	
6	☐NO ☐YES (Size:)	☐NO ☐YES (Degree:)	☐OK ☐NG	☐OK ☐NG	☐ DONE	
7	☐NO ☐YES (Size:)	☐NO ☐YES (Degree:)	☐OK ☐NG	☐OK ☐NG	☐ DONE	
8	☐NO ☐YES (Size:)	☐NO ☐YES (Degree:)	☐OK ☐NG	☐OK ☐NG	☐ DONE	
9	☐NO ☐YES (Size:)	☐NO ☐YES (Degree:)	☐OK ☐NG	☐OK ☐NG	☐ DONE	
10	☐NO ☐YES (Size:)	☐NO ☐YES (Degree:)	☐OK ☐NG	☐OK ☐NG	☐ DONE	

TRAFFIC SIGNAL SYSTEM MAINTENANCE CHECK SHEET

(Handhole)

Junction : _____

Need to maintenance : Every 12 Months

Date : / /

No. of handhole	Damages of cover (split / crack)	Damages of box (crack / chip)	Check inside (water / garbage)	Damages of cables coating	Cleaning	Remarks
1	☐NO ☐YES (Size:)	☐NO ☐YES (Size:)	☐OK ☐NG	☐OK ☐NG	☐ DONE	
2	☐NO ☐YES (Size:)	☐NO ☐YES (Size:)	☐OK ☐NG	☐OK ☐NG	☐ DONE	
3	☐NO ☐YES (Size:)	☐NO ☐YES (Size:)	☐OK ☐NG	☐OK ☐NG	☐ DONE	
4	☐NO ☐YES (Size:)	☐NO ☐YES (Size:)	☐OK ☐NG	☐OK ☐NG	☐ DONE	
5	☐NO ☐YES (Size:)	☐NO ☐YES (Size:)	☐OK ☐NG	☐OK ☐NG	☐ DONE	
6	☐NO ☐YES (Size:)	☐NO ☐YES (Size:)	☐OK ☐NG	☐OK ☐NG	☐ DONE	
7	☐NO ☐YES (Size:)	☐NO ☐YES (Size:)	☐OK ☐NG	☐OK ☐NG	☐ DONE	
8	☐NO ☐YES (Size:)	☐NO ☐YES (Size:)	☐OK ☐NG	☐OK ☐NG	☐ DONE	
9	☐NO ☐YES (Size:)	☐NO ☐YES (Size:)	☐OK ☐NG	☐OK ☐NG	☐ DONE	
10	☐NO ☐YES (Size:)	☐NO ☐YES (Size:)	☐OK ☐NG	☐OK ☐NG	☐ DONE	

POWER BACK UP SYSTEM MAINTENANCE CHECK SHEET

(Automatic Engine Generator / Automatic Voltage Regulator / Uninterruptible Power System)

Need to maintenance : Every 6 Months

Junction : _____ Date : / /

Equipment	Item	Result		Remarks
AEG	Damages of body (flaw, rust, etc.)	☐ OK	☐ NG	
	Check of engine oil leakage	☐ OK	☐ NG	
	Replacement of engine oil	☐ DONE	Litter	
	Cleaning of oil filter	☐ DONE		
	Cleaning of fuel filter	☐ DONE		
	Drainage of water in fuel tank	☐ DONE		
	Cleaning of air cleaner	☐ DONE		
	Cleaning outside / inside	☐ DONE		
	Washing of an intake filter	☐ DONE		
	Check of exost pipes	☐ OK	☐ NG	
	Tightening of bolts / screws	☐ OK	☐ NG	
	Connection of wires / terminals	☐ OK	☐ NG	
	Damages of cables/ wires coating	☐ OK	☐ NG	
	Value of time / date	☐ OK	☐ RESET	
	Measurement of power output		V	
	Measurement of current output		A	
AVR	Cleaning	☐ DONE		
	Connection of wires / terminals	☐ OK	☐ NG	
	Damages of cables/ wires coating	☐ OK	☐ NG	
	Measurement of power intput		V	
	Measurement of current input		A	
	Measurement of power output		V	
	Measurement of current output		A	
UPS	Cleaning of body / intake part	☐ DONE		
	Connection of wires / terminals	☐ OK	☐ NG	
	Damages of cables/ wires coating	☐ OK	☐ NG	
	Battery self test	☐ OK	☐ NG	

AUTOMATIC ENGINE GENERATOR REFUEL SHEET

Junction : _____

Date	Amount of refuel	Accumulation running time	Check of error indicartion		Check of fuel leakage		Check of unusual condition while running		Remarks
/ /	L	H	☐OK	☐NG	☐OK	☐NG	☐OK	☐NG	
/ /	L	H	☐OK	☐NG	☐OK	☐NG	☐OK	☐NG	
/ /	L	H	☐OK	☐NG	☐OK	☐NG	☐OK	☐NG	
/ /	L	H	☐OK	☐NG	☐OK	☐NG	☐OK	☐NG	
/ /	L	H	☐OK	☐NG	☐OK	☐NG	☐OK	☐NG	
/ /	L	H	☐OK	☐NG	☐OK	☐NG	☐OK	☐NG	
/ /	L	H	☐OK	☐NG	☐OK	☐NG	☐OK	☐NG	
/ /	L	H	☐OK	☐NG	☐OK	☐NG	☐OK	☐NG	
/ /	L	H	☐OK	☐NG	☐OK	☐NG	☐OK	☐NG	
/ /	L	H	☐OK	☐NG	☐OK	☐NG	☐OK	☐NG	
/ /	L	H	☐OK	☐NG	☐OK	☐NG	☐OK	☐NG	
/ /	L	H	☐OK	☐NG	☐OK	☐NG	☐OK	☐NG	
/ /	L	H	☐OK	☐NG	☐OK	☐NG	☐OK	☐NG	
/ /	L	H	☐OK	☐NG	☐OK	☐NG	☐OK	☐NG	
/ /	L	H	☐OK	☐NG	☐OK	☐NG	☐OK	☐NG	
/ /	L	H	☐OK	☐NG	☐OK	☐NG	☐OK	☐NG	
/ /	L	H	☐OK	☐NG	☐OK	☐NG	☐OK	☐NG	
/ /	L	H	☐OK	☐NG	☐OK	☐NG	☐OK	☐NG	
/ /	L	H	☐OK	☐NG	☐OK	☐NG	☐OK	☐NG	
/ /	L	H	☐OK	☐NG	☐OK	☐NG	☐OK	☐NG	
/ /	L	H	☐OK	☐NG	☐OK	☐NG	☐OK	☐NG	
/ /	L	H	☐OK	☐NG	☐OK	☐NG	☐OK	☐NG	
/ /	L	H	☐OK	☐NG	☐OK	☐NG	☐OK	☐NG	
/ /	L	H	☐OK	☐NG	☐OK	☐NG	☐OK	☐NG	
/ /	L	H	☐OK	☐NG	☐OK	☐NG	☐OK	☐NG	
/ /	L	H	☐OK	☐NG	☐OK	☐NG	☐OK	☐NG	
/ /	L	H	☐OK	☐NG	☐OK	☐NG	☐OK	☐NG	

TRAFFIC SIGNAL SYSTEM / POWER BACK UP SYSTEM WORK RECORD SHEET

Junction : _____

Date	Equipment	Used materials / parts and amount	What work you did
/ /			
/ /			
/ /			
/ /			
/ /			
/ /			
/ /			
/ /			
/ /			
/ /			

TRAFFIC SIGNAL SYSTEM / POWER BACK UP SYSTEM MAINTENANCE TOOLS / INSTRUMENT

Item	Type	Purpose for use	Remarks
Screwdriver	Plus	Tighten each screws	Prepare various size for necessity
Screwdriver	Minus	Tighten each screws / Connect wires to no-screw terminal block	Prepare various size for necessity
Spanner		Tighten each bolts / nuts	Prepare various size for necessity
Nippers		cut the wires / cables	
Terminal crimping plier		Crimp terminal to the end of wires	Prepare various size for necessity
Key for Traffic signal controller	TSEC	Open the door of traffic signal controller	
	Kyosan		
Key for Automatic Engine Generator		Open the door of automatic engine generator	
Key for Control house		Open the door of control house	
Pulling hooks for handohole		Open the cover of handhole	
Voltmeter		Measure ouotput / input power	
Cloth		Clean / Wipe	
Sandpaper		Remove rust	
Vinyl tape		Protect damaged coating of wires / non-terminaled wires	
Level		Measure inclination / bend degrees	
Scissors / Cutter / Knife		Remove alien substance	
Brush / Broom / Air spouter		Clean	
Soap		Clean equipment bodies / air cleaner / intake filter	
Watch / Calendar		Reset time / date	
Oil pan		Store drained oil / water	
Oil pourer / Fuel pourer		Pour oil / fuel	
Truck mount aerial work platform		Work aerial place (traffic signal light etc.)	Use if necessary

TRAFFIC SIGNAL SYSTEM / POWER BACK UP SYSTEM SPARE PARTS LIST

Equipment	Item	Type	Amount	Remarks
Traffic signal controller	Power unit		2	for TSEC controller
	Noise filter	MAS-1210-33	2	for TSEC controller
	Main power breaker	KM-2S 30A	2	for TSEC controller
	Traffic light breaker	BS1113	2	for TSEC controller
	Surge absorber	ERZV14D221	40	for TSEC controller
	Surge absorber	ERZV14D391	10	
	Surge absorber	ERZV14V330CS	20	
	Surge absorber	ERZV14V221CS	15	
	Surge absorber	ERZV14V391CS	10	
Traffic signal light	Bulb	240V	10	
	Traffic signal light (LED)	Vehicle GYR	1	
	Traffic signal light (LED)	Pedestrian	1	
	Traffic signal light (LED)	Vehicle 1 arrow	1	
AVR	Thyristor board		1	
AEG	Fan motor		1	
	Fuse	10A	4	
	Fuse	1A	2	
	Fuse	5A	16	
	Light oil		50	for refuel / clean filters
	Engine oil	SAE 10W-30	3	
	Oil filter		1	
	Fuel filter		1	
	Air filter		1	
	Surge absorber	ERZV20D271	20	

PART-3: OPERATION MANUAL

3-1: POWER SUUPLY

Matsunaga

OPERATING INSTRUCTIONS

AUTOMATIC VOLTAGE REGULATOR

TSA-1030-CJ

株式会社松永製作所

Matsunaga Manufacturing Co., Ltd.

CAUTIONS FOR SAFETY

Read "CAUTIONS FOR SAFETY" well before the operation of the unit and treat the unit properly.

☆The below mentioned warnings are for your safe and secure use of the unit in order to avoid troubles and harms. Wrong treatments may cause some dangerous situations, which we here devide to three categories as "DANGER" "WARNING" & "CARE". Follow surely to this important notice.

☆The marks and their meanings are as the below.

DANGER

There have potential danger of death or serious injury. And the emergency measure shall be taken, if this situation happens. (highest urgency and danger)

WARNING

There have potential danger of death or serious injury.

CARE

There have potential danger of slight injury and material damage.

MEANINGS OF MARKS

PROHIBITION

NECESSARY PRACTICE

Keep several limitations prescribed here and do not excessive treatments and uses. And make properly routine checks and maintenances for previnting all troubles.
This "CAUTIONS FOR SAFETY" must be kept beside of persons in charge of operation and/or maintenance.

DANGER

CONNECTING WORKS TO THE POWER SOURCE

(ELECTRIC WORK)
Several regulations are prepared depend on classes of facilities. The work must be followed to the regulations of each country.

(INSTALLATION, CHECK, REPAIR & OPERATION OF CHARGING ROUTE)

Only engineers who have studied specially about electricity must attend.

(GROUNDING WORK)
Grounding work must follow to regulations of each countries.

Do not connect absolutely grounding wire with gus tube.
＊Danger of death and serious injury.

LOCATION OF INSTALLATION

Do not install the unit at where explosives and/or combustibles are kept or will be used.

＊The unit is made of metal. So corrosion, rust and electrical spark may cause explosion and/or fire.

(EXPLOSIVES)

(COMBUSTIBLES)
(INGITIBLES)
(CAMBUSTIBLE GUS)

(OXIDES)

Matsunaga

No. 957PL1A

WARNING

Fix the unit to the floor, pillar and wall in order not to fall down or move by earthquack.
＊Falling down may cause injury.

Do not put anything and step on the unit.
＊Radiation will be affected and the inside temperature will rise.
＊Objects on the unit may be scorched by heat.
＊Top cover of the unit may be curved by heat.

Do not disassemble, repair and/or reconstruct the unit recklessly.
＊It may cause malfunction, trouble and/or burnt.

Do not touch where this mark is sealed on at checking inside of the unit, even if the input power is turned off.
＊It may cause death or serious injury by electric shock.

Do not touch the terminals and studs during operation, which this mark is sealed on.
＊It may cause death or serious injury by electric shock.

TRANSPORTATION & MOVE

Avoid rain and water-drops.
＊It may cause electric shock and malfunction.

Do not put down sideways. Fix the unit carefully in order not to fall down by vibration.
＊It may cause damages of inside components and malfunction.

Hang up the unit, using all hanger-bolts.
＊It may cause serious injury by drop of the unit.

CARE

Do not change carelessly adjusting resistors on P.C. Board. Because the values are already set properly at our factory.
＊It may cause damages of your equipments, unstable functions and/or troubles of the unit.

Do not do a insulating resistance test between input(& output) and E-terminal(Frame). The test for insulated products must be done only between Input and Output.
＊It may cause damage and/or malfunction of the unit.

In case of meggar test, use instrument of DC500V.
＊It may cause damage and/or malfunction of P.C. Board.

Do not keep the unit under the below mentioned locations for temporary storage or unused for a certain period.
- ●Where water-drops come into.
- ●Where relative humidity rises more than 85%.
- ●Where ambient temp. drops under-10℃ (or makes dews) and rise over+50℃.
- ●Where there have gus and oxide objects, which makes corrosion of metal.
- ●Where there have dust, metal powder and electric conductive powder.
- ●Where receives vibrations and shocks.
- ●Where sun-shine comes into directly.

＊These may cause electric shock, injury, fire, malfunction of the unit.

(MAINTENANCE & ROUTIN CHECK)
Turn off the main switch(input) in case of maintenance and routin check.
Do not touch your hand and body to electric conductive part of the unit.
＊It may cause electric shock and injury.
■Inside components will be emaciated in extreamely rapid, if maintenance and routin check are not effected. Our warranty excludes some troubles caused by lack of maintenance or routin check.

(ACCIDENT AT OPERATION)
Turn off the main switch and solve causes. Restart the operation.
＊It may cause electric shock, damage and/or fire.

取 扱 説 明 書
OPERATING INSTRUCTIONS

○添付の標準品取扱説明書を、御参照下さい。
Please refer to the attached operating instructions for standard articles.
○下記の項目以外の説明は、標準品取扱説明書と同じです。
Descriptions of items other than the following, are the same as those listed in the operating instructions for standard articles.

３．仕様
Specifications

４ＧＨ－１８３６３Ａ　による。

４－４．保護回路
Protection

１）T1, T4, L1, L2, L3, L4にサーモスタットを取付け、温度が１２０℃以上になった時、入力ブレーカの引き外しコイルを動作させ遮断します。
This unit is mounted thermostats on T1, T4, L1, L2, L3 and L4 as to trip the input circuit breaker, when tempereture is over 120℃.

２）入力電圧が１８０Ｖを外れると、低電圧保護回路が動作し出力の電磁接触器を遮断します。また、入力電圧が１８０Ｖ以上を約５秒間継続すると、自動的に復帰します。
If the input voltage of the regulator deviates by below 180V the low voltage protecton circuit intervenes and open the magnetic switch.
And when input voltage resumes within below 180V at continue approx. 5 seconds of the magnetic switch is automatically closed.

５．外観・計装品
Panel Features

３ＧＭ－７０７６Ａ　　による。

９．入力電源容量
Power Supply

本装置への入力電源容量は、最大値で定格出力容量の１．９７倍となります。したがって、入力電源および入力側配線材は、この最大容量を満足する物を使用して下さい。
The power input may reach 1.97 times the rated power output of the regulator. When selecting the power source and connecting cables between the power source and the regulator, keep this in mind.

１４．主回路
Circuit Diagram

４ＧＨ－１８３６４　　による。

１５．配線材と電圧降下
Recommended Connecting Cables

	端子寸法 Terminals and stud bolts	配線材径 Cross section of cable(mm²)	電圧降下 Voltage drop(v/m)
入力側 Input side	M5	5.5	0.174
出力側 Output side	M5	5.5	0.194
接　地 Grounding	M5	2.0	―――

変更事項 REVISIONS 日付 DATE	内容 CONTENTS	担当 REV.
	A.	
	B.	
	C.	
	D.	
	E.	

材質 MATERIALS	処理 TREATMENT	数量 QUANTITY

第三角法 THIRD ANGLE PROJECTION	単位 UNITS	尺度 SCALE
	%	／

承認 APPROVED BY	検図 CHECKED BY	製図 DRAWN BY	設計 DESIGNED BY
佃		大金	大金

年月日 ISSUED 2006．1．24

名称 TITLE	取扱説明書 OPERATING INSTRUCTIONS
型名 MODEL	TSA－1030－CJ
図番 DRAWING No.	4GH－18626

株式会社 松永製作所 Matsunaga Manufacturing Co., Ltd.

15.9.2.000㊤

Matsunaga

サイリスタ絶縁型定電圧電源装置仕様
AC AUTOMATIC VOLTAGE REGULATOR SPECIFICATIONS (ISOLATED THYRISTOR TYPE)

型名 MODEL	TSA－1030－CJ
冷却方式 COOLING SYSTEM	乾式自冷式 AIR-COOLED TYPE
相数 PHASE	1 φ SINGLE PHASE
定格周波数 RATED FREQUENCY	50/60 Hz (切換式) (CHANGE-OVER)
周波数変動範囲 FREQUENCY VARIATION	± 2 Hz
定格出力容量 RATED CAPACITY	3 kVA
定格入力電圧 RATED INPUT VOLTAGE	AC 240 V
入力電圧変動範囲 INPUT VOLTAGE VARIATION	AC 180 V ～ 260 V
定格出力電圧 RATED OUTPUT VOLTAGE	AC 100 V
定電圧精度 ACCURACY	± 1.5 % 以内 WITHIN ± 1.5 %
出力電圧調整範囲 ADJUSTABLE RANGE OF OUTPUT VOLTAGE	± 3 %
負荷変動範囲 LOAD VARIATION	0～100 %
負荷力率 LOAD POWER FACTOR	100 %
波形歪率 DISTORTION FACTOR	5 % 以下 (発生歪) LESS THAN 5 % INTRODUCED
応答時間 RESPONSE TIME	秒以内 (入力電圧 15% 急変時) 0.08 sec OR LESS (15% VOLTAGE VARIATION)
効率 EFFICIENCY	以上 (入力 180 V 定格負荷時) 85 % OR MORE (INPUT 180 V IN RATED LOAD)
力率 POWER FACTOR	以上 (入力 180 V 定格負荷時) 73 % OR MORE (INPUT 180 V IN RATED LOAD)
絶縁抵抗 INSULATION RESISTANCE	以上 (DC 500V メガー) 5 MΩ MORE THAN (DC 500V MEGGER)
絶縁耐圧 DIELECTRIC STRENGTH	AC 1500 V (1分間) (1MIN)
温度上昇 TEMPERATURE RISING	B 種 以下 (温度計法) CLASS B. 70 ℃ OR LESS (THERMOMETER METHOD)
周囲温度 AMBIENT TEMPERATURE	0℃ ～ 40℃
相対湿度 RELATIVE HUMIDITY	30 % ～ 85 %
塗装色 PAINTING COLOR	正面 FRONT PANEL:2.5Y9/1 レザートン LEATHER-TONE (参考：淡黄色) (REFERENCE:CREAM)
	外装 OUTSIDE: 2.5PB3.5/10 レザートン LEATHER-TONE (参考：青色) (REFERENCE:BLUE)
重量 WEIGHT	約 APPROX. 180 kg

保護回路 Protection

1. T1,T4,L1,L2,L3,L4にｻｰﾓｽﾀｯﾄを取付け,温度が120℃以上になった時,入力ブレーカの引き外しコイルを動作させ遮断します。
This unit mounted thermostats on T1,T4,L1,L2,L3 and L4 as to trip the input circuit breaker, when temperature is over 120℃.
2. 入力電圧が１８０Ｖを外れると、低電圧保護回路が動作し出力の電磁接触器を遮断します。また、入力電圧が１８０Ｖ以上を約５秒間継続すると自動的に復帰します。
If the input voltage of regurator deviates by below 180V the low voltage protection circuit intervenes and open the magnetic switch.
And when input votage resumes within below 180V at continue approx. 5seconds of the magnetic switch is automatically closed.

外形図 OUTLINE DRAWING	図番 DRAWING No. 3GM－7076A
回路図 CIRCUIT DIAGRAM	図番 DRAWING No. 4GH－18364

変更事項 REVISIONS 日付 DATE	内容 CONTENTS	担当 REV
06.1.23	A 整備	大金
	B.	
	C.	
	D.	
	E.	

材質 MATERIALS	処理 TREATMENT	数量 QUANTITY

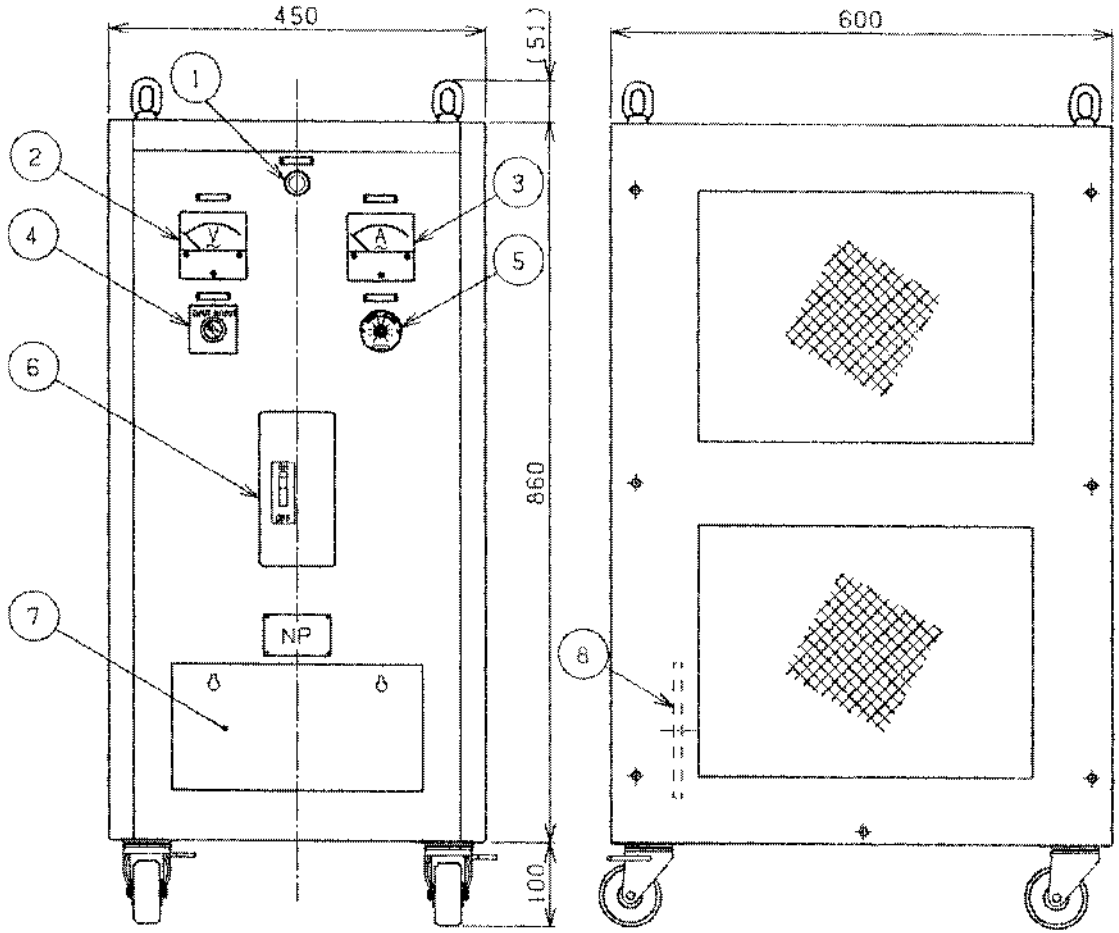
第三角法 THIRD ANGLE PROJECTION	単位 UNITS	尺度 SCALE
	%	／

承認 APPROVED BY	検図 CHECKED BY	製図 DRAWN BY	設計 DESIGNED BY
佃		大金	大金

年月日 ISSUED Oct. 30 2004

名称 TITLE	仕様事項書 SPECIFICATIONS
型名 MODEL	TSA－1030－CJ
図番 DRAWING No.	4GH－18363A

株式会社 松永製作所 Matsunaga Manufacturing Co.,Ltd.



No.	名称 NAME	小銘板表示 INDICATION
1	表示灯 PILOT LAMP	SOURCE
2	電圧計 VOLTMETER	IN&OUT VOLTAGE
3	電流計 AMMETER	OUTPUT CURRENT
4	電圧計切換スイッチ VOLTMETER TRANSFER SWITCH	V-METER TRANSFER
5	出力電圧設定器 OUTPUT VOLTAGE ADJUSTOR	VOLTAGE ADJUSTOR
6	サーキットブレーカ CIRCUIT BREAKER	
7	端子板カバー COVER OF THE TERMINALS PLATE	
8	端子板 TERMINALS PLATE	
9		
10		

変更事項 REVISIONS 日付 DATE	内容 CONTENTS	指令 REV
1.11.31	A ~TER →← ~TOR	2版
	B	
	C	
	D	
	E	

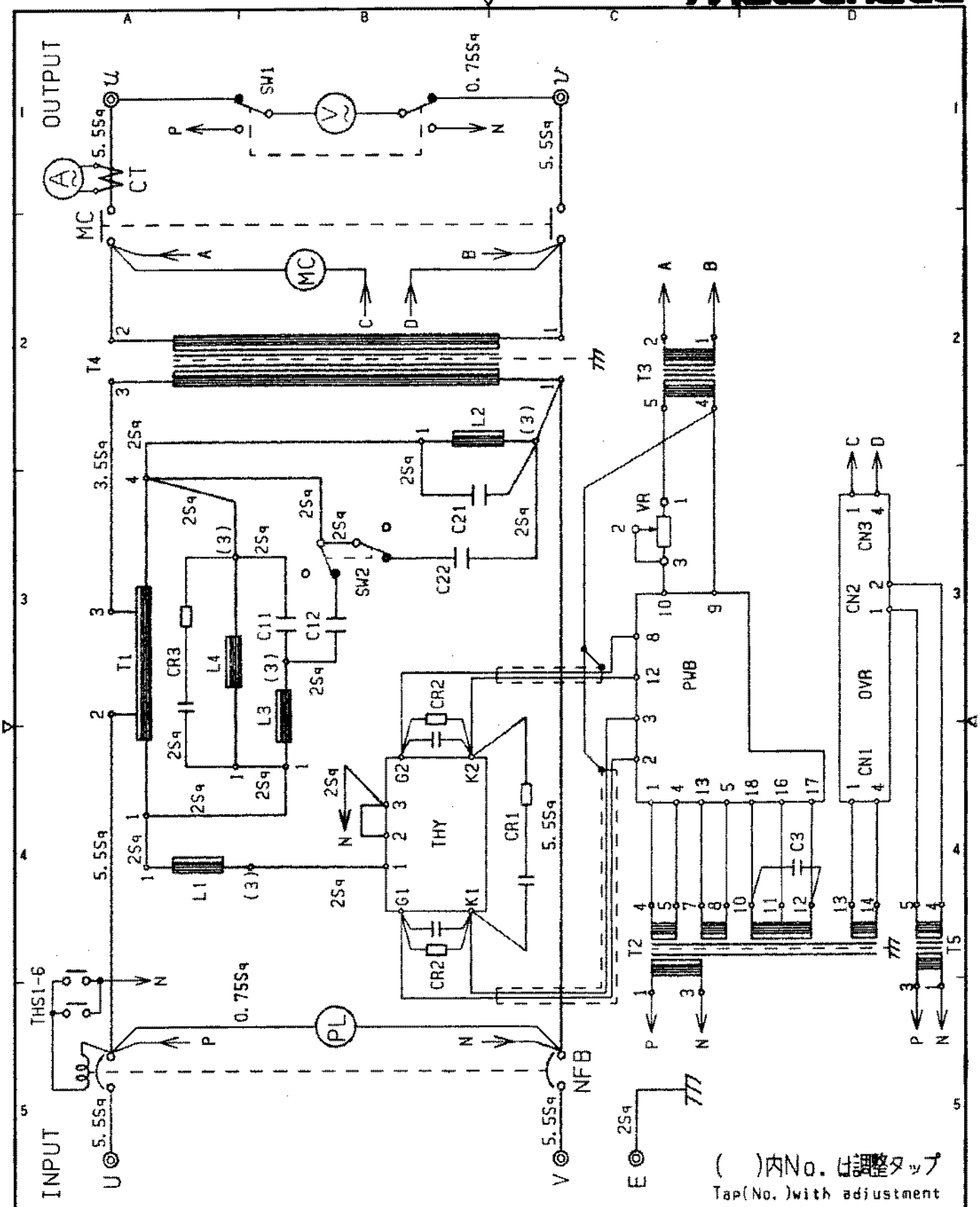
材質 MATERIALS	処理 TREATMENT	数量 QUANTITY
第三角法 THIRD ANGLE PROJECTION	単位 UNITS %	尺度 SCALE 1/6

承認 APPROVED BY	検図 CHECKED BY	製図 DRAWN BY	設計 DESIGNED BY
Y. Kuwaki	H. Sato	J. Ohsone	J. Ohsone

年月日 ISSUED OCT. 26 1985

名称 TITLE	外形図 OUTLINE DRAWING
型名 MODEL	
図番 DRAWING No	3GM-7076A

株式会社松永製作所 Matsunaga Manufacturing Co.,Ltd.

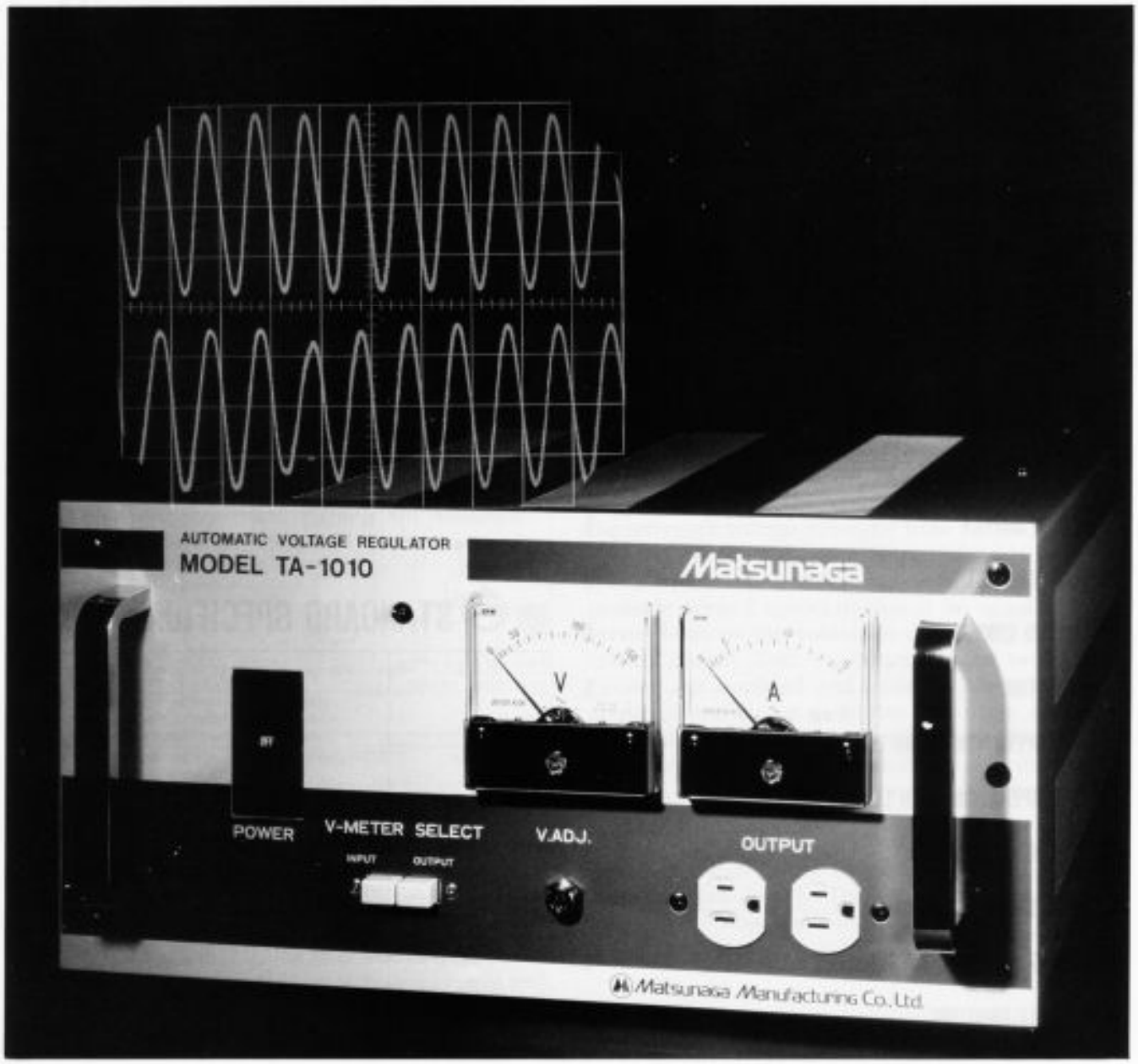


変更事項 REVISIONS			材質 MATERIALS	処理 TREATMENT	数量 QUANTITY	名称 TITLE	回路図 CIRCUIT DIAGRAM
日付 DATE	内容 CONTENTS	担当 REV					
	A.		第三角法 THIRD ANGLE PROJECTION	単位 UNITS %	尺度 SCALE —	型名 MODEL	
	B.						
	C.		承認 APPROVED BY T. Tukuda	検図 CHECKED BY	製図 DRAWN BY J. Ohgane	設計 DESIGNED BY J. Ohgane	図番 DRAWING No. 4GH-18364
	D.						
	E.		年月日 ISSUED Oct.. 29. 2004				株式会社松永製作所 Matsunaga Manufacturing Co.,Ltd.

AVR TA·TSA | AUTOMATIC VOLTAGE REGULATORS THYRISTOR TYPE

OPERATING INSTRUCTIONS

■ Make sure to read this operating instructions before using this equipment. And keep this manual with much care in order to facilitate the routine check-up and avoid the unexpected malfunction of the equipment.



Matsunaga Manufacturing Co., Ltd.

CONTENTS

1 DESCRIPTION

The Series TA and TSA are non-mechanical, thyristor type automatic voltage regulators. When the output voltage of the regulator deviates from the rated value due to variations of the input voltage or the load, the deviation voltage is detected by a high-sensitivity RMS coverter IC. The deviation voltage is amplified, converted into control signal and fed to the thyristor circuit. The thyristor circuit restores the output voltage to the rated value.

The RMS converter IC incorporated in the detector circuit improves both reliability and durability. The Proportional and Integral (PI) control system eliminates both the steady-state deviation and the overshooting of the output voltage. The drift of the output voltage at the initial transient is also minimized and the temperature coefficient is very small.

The Series TSA is isolated and electrostatically shielded (between the primary and secondary sides).

2 FEATURES

- RMS detection.
- High accuracy and high response speed.
- Low distortion. The pulse-shaped switching distortion introduced in the thyristor circuit is filtered.
- High efficiency and a compact and lightweight construction.
- Even if the output terminals are shorted, the thyristor is not damaged.
- Special circuit is provided to prevent the malfunction of the thyristor.
- Maintenance free.
- Series TSA is isolated and electrostatically shielded (between the primary and secondary sides). The noise contained in the line voltage is reduced.

3 STANDARD SPECIFICATIONS

Input and output voltage	1φ100V, 1φ200V, 3φ200V
Input voltage variation	−15% to +15%
Frequency	48Hz to 52Hz or 58Hz to 62Hz (models for 1φ, 10kVA and downwards are compatible with both 50Hz and 60Hz)
Output voltage accuracy	Within ±0.4% for Series TA Within ±1% for Series TSA
Output voltage fine adjustment	±3% of the rated value
Load variation	0 to 100%
Waveform distortion	Less than 3% introduce
Response time	Within 0.08 to 0.15 sec. (against 15% input voltage variation)
Efficiency	More than 85% for models for 2kVA and downwards More than 90% for models for 3kVA and upwards (at the lowest input voltage and under rated load)
Power factor	More than 0.75 for models for 2kVA and downwards More than 0.8 for models for 3kVA and upwards (at the lowest input voltage and under rated load)
Ambient temperature	0 to 40°C

Relative humidity	30 to 85%
Temperature rise	Less than 50°C(under rated load for class A insulation) Less than 70°C(under rated load for class B insulation) (at hottest point by thermometer)
Insulation resistance	More than 10 MΩ (small capacity units), More than 3 MΩ (large capacity units), measured at DC 500V
Dielectric strength	Tested at 1500 VAC for 1 min.

*Unbalance of the loads is allowed up to 20% for the models for three-phase.

- With respect to the models with less than 2kVA, Efficiency should be over 85% and power factor should be 0.75 as standards.
- In referrence to the single phase models with less than 10kVA frequency 50Hz or 60Hz is compatible. The other models are manufactured as the special type for only 50Hz or 60Hz.

4 CIRCUIT DESCRIPTION

Fig. 1 is the block diagram of the Series TA and TSA. In the case of the models for three-phase, Fig. 1 shows the block diagram for each phase.

- Deviation voltage detector and phase control circuit
  The deviation voltage is detected and fed to the phase control circuit through the amplifier. The phase control circuit controls the thyristor circuit to restore the output voltage.
- Thyristor circuit
  Controlled by the signal from the phase control circuit, maintain the output voltage of the regulator constant by varying the phase angle of the thyristor.
- Waveform compensating circuit
  The harmonic distortion introduced in the thyristor circuit is eliminated.

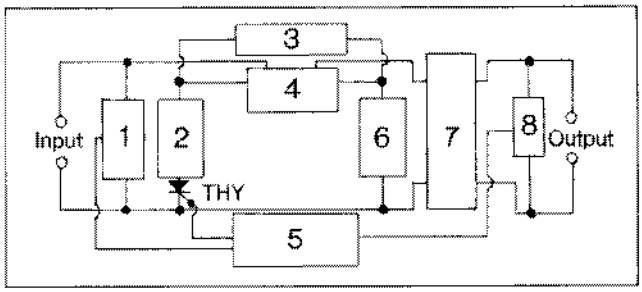


Fig. 1 Block diagram

1 : Control transformer
2 : Series reactor
3 : Waveform compensating circuit
4 : Control reactor
5 : Deviation voltage amplifier and phase control circuit
6 : Parallel reactor
7 : Isolated and electrostatically shielded transformer (Series TSA only)
8 : Detector
THY : Thyristor

4-1 DEVIATION VOLTAGE DETECTOR AND PHASE CONTROL CIRCUIT

The block diagram of these circuits are shown in Fig. 2.

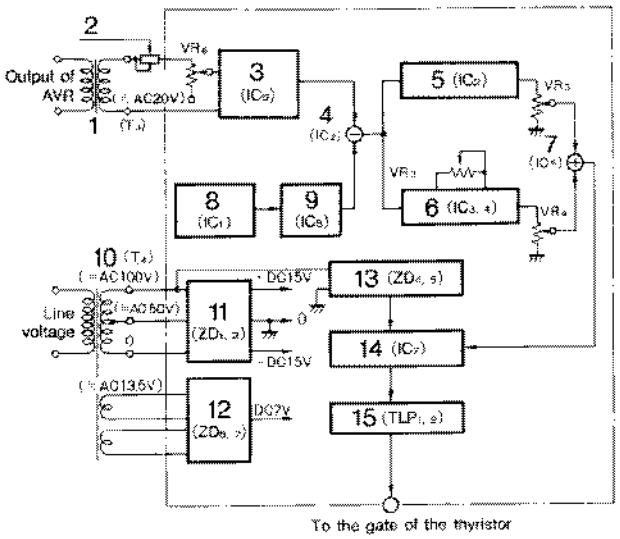


Fig. 2 Block diagram of the deviation voltage detector and the phase control circuit

(Main elements of each section are given in the parenthesis.)

1 : Detecting transformer
2 : Output voltage adjustor
3 : RMS converter circuit
4 : Subtracter
5 : Proportional (P) control circuit
6 : Integral (I) control circuit
7 : Adder
8 : Soft start circuit
9 : Reference voltage generator
10 : Control transformer
11 : Stabilized DC power supply
12 : Stabilized DC power supply
13 : Synchronizing signal generator
14 : Phase control circuit
15 : Photo-coupler

The output voltage of the regulator is dropped to about 20V by the detecting transformer and fed to the RMS converter circuit. The RMS converter generates the DC voltage proportional to the root mean square (effective value) of the AC input voltage. Then, the subtracter subtract the reference voltage generated in the reference voltage ganerator from the output of the RMS converter. Using the output of the subtracter, the proportional and the integral control circuits generate control signals (It should be noted that IC_2 serves both as the subtracter and the proportional control circuit). Both the outputs of the two control circuits are amplified and added in the adder. The phase control circuit generates the trigger signal for the thyristor, using the outputs of the adder and the synchronizing signal generator. Finally, the trigger signal is fed to the gate of the thyristor through the isolating photo coupler.

The PI (Proportional and Integral) control system improves the accuracy of the output voltage of the regulator considerably. The soft start circuit restricts the output voltage for a short time after the regulator is switched on.

4-2 THYRISTOR CIRCUIT

When the output voltage becomes lower than the rated value, the phase angle of the thyristor (THY) becomes smaller. Therefore, the impedance of the series reactor circuit (L_1 and THY) decreases and current flows mainly through L_1, In this case, power input is mainly supplied between a and b of the control reactor (T_1) and T_1 serves as a step-up transformer(Fig. 3).

When the output voltage exceeds the rated value, the phase angle of THY becomes larger and the impedance of the series reactor circuit (L_1 and THY) increases. Therefore, current flows mainly through the parallel reactor (L_2) and power input is mainly supplied between b and c of T_1. T_1 serves as a step-down transformer (Fig. 4).

4-3 WAVEFORM COMPENSATING CIRCUIT

The output of the thyristor circuit contains odd harmonics. These harmonics are eliminated with the aid of the resonance circuit comprised of reactors (L_3, L_4) and a capacitor (C_1) and with the aid of a capacitor (C_2) connected in parallel to L_2 (Fig. 5).

1 : Waveform compensating circuit

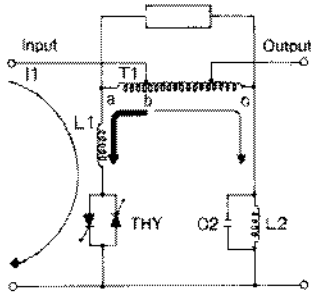


Fig. 3

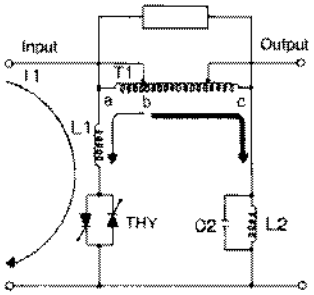


Fig. 4

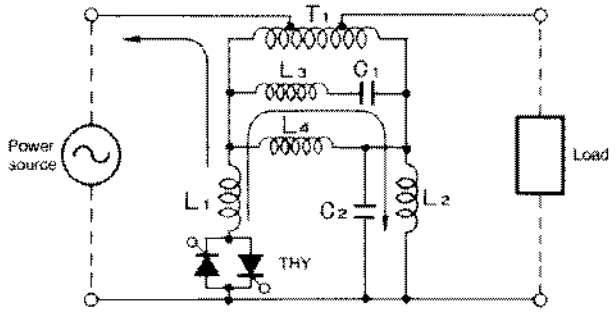


Fig. 5 Waveform compensating circuit

5 PANEL FEATURES

❶ Pilot lamp: Lights up when the power switch (no-fuse breaker) is turned on.

❷ Voltmeter: Indicates the output voltage. In the case of the models for single-phase, input voltage can also be monitored by turning the voltmeter function switch.

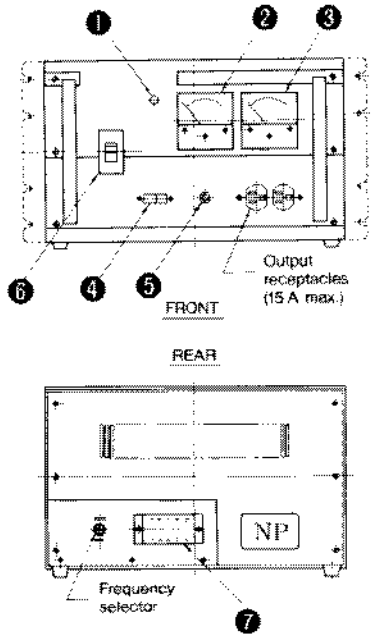


Fig. 6 Built-in type

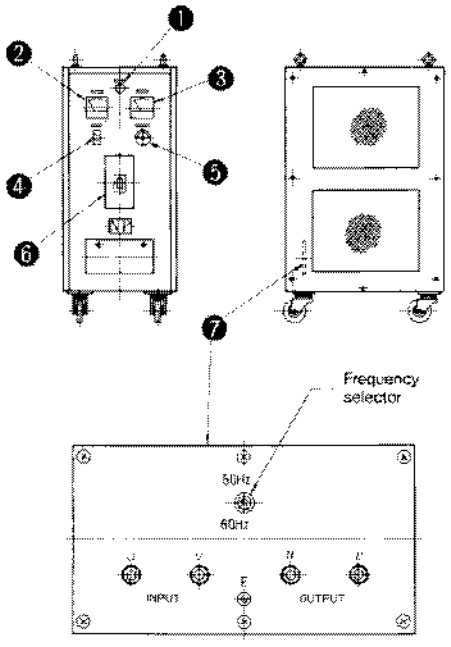


Fig. 7 Single-phase, stand-alone type

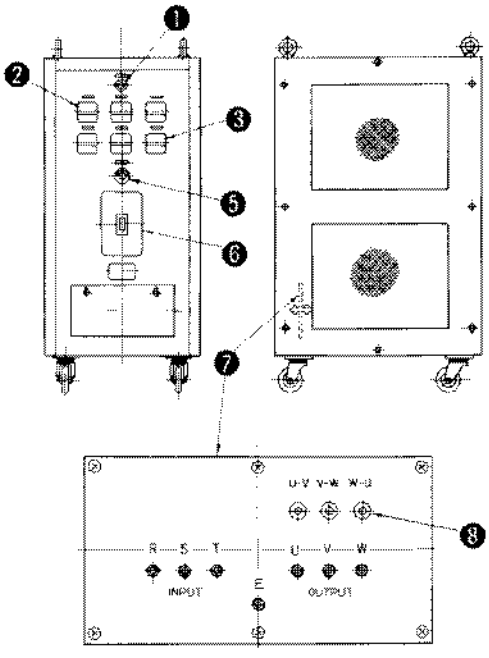


Fig. 8 Three-phase, stand-alone type

❸ Ammeter: Indicates the output current.
❹ Voltmeter function switch: For the models for single-phase only. Either the output or input voltage can be monitored by turning this switch.
❺ Output voltage adjustor: The output voltage can be raised or lowered by ±3% by turning this dial clockwise or counterclockwise.
❻ Power switch (no-fuse breaker)
❼ Input and output terminals: Input terminals are marked, "U", and "V" (single-phase), "R", "S" and "T" (three-phase). Output terminals are marked, "u" and "v" (single-phase), "U", "V" and "W" (three-phase). The grounding terminal is marked "E".
❽ Line voltage fine adjustors: For the models for three-phase only. The line voltages can be adjusted when the regulator is at no load or connected to a balanced load. When adjusting the line voltages, disconnect the balanced load.

6 DELIVERY INSPECTION

When received, the regulator should be checked for the followings:

- Correct model number.
- Damages in transit.
- Loosen screws or terminals.

If any trouble is discovered, please inform us or our dealer.

7 STORAGE OR TRANSIT

When the regulator is temporarily stored or unused for long periods, care should be taken as follows.

7-1 STORAGE

Environmental requirements for storing the regulator are as follows.

- Do not expose the regulator to rain, water or moisture.
- Keep the regulator free from corrosive gases or liquids, dust or iron filings.
- Ambient temperature should be between −10°C and +50°C.
- Store the regulator on a vibration-free floor.

7-2 INSULATION RESISTANCE TEST

If the regulator has been stored for a long time it should be tested for insulation resistance before using.

After turning the power switch ON, measure the insulation resistances between the input/output terminals and the grounding terminal using an insulation resistance tester (Megger). In the case of the Series TSA, the insulation resistance between the input and output terminals should also be measured.

7-3 TRANSIT

Avoid excessive vibration or shock when transporting the regulator.

8 INSTALLATION

8-1 ENVIRONMENTAL REQUIREMENTS

See "7-1. Storage". For the ambient temperature, see "3. Standard Specifications".

8-2 LOCATION

Make sure the regulator has enough cooling space above and around it (see Figs. 9 and 10).

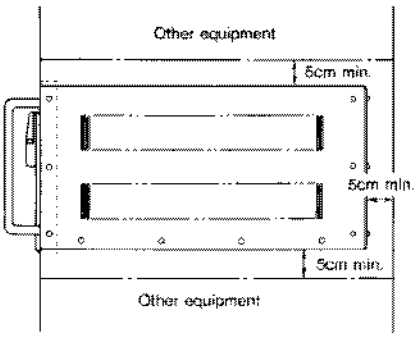


Fig. 9 Built-in type

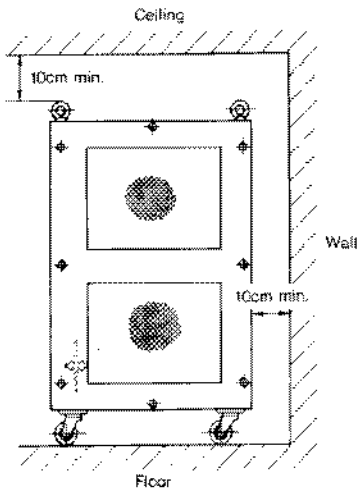


Fig. 10 Stand-alone type

9 POWER SUPPLY

The power input may reach 1.65 times the rated power output of the regulator (at full load, at the lowest input voltage, i.e., −15%, efficiency 90% and power factor 0.8). When selecting the power source and connecting cables between the power source and the regulator, keep this in mind.

10 LOAD CONNECTION

When the load is distant from the regulator, take care of the voltage drop which occurs in the cables.

Use of thermoplastic-covered wires for 600 VAC or cabtyre (tough-rubber sheathed) cables is recommended. When selecting the cable, crimp-style terminals and stud bolts, please refer to Table, Section 15.

11 GROUND CONNECTION

The grounding cable should be made as short as possible. Select the grounding cable referring to Table, Section 15.

Never connect the grounding cable to the grounding rod to which heavy current equipments are already connected.

12 OPERATION

After the connection, check for the followings:

- Check the connections between the power source and the regulator, between the regulator and the load and between the regulator and the grounding rod. In the case of the models for three-phase, care should also be taken to the polarity of the power source and the load.
- Check for loosen bolts at the terminals.
- Check whether the frequency selector is turned to the appropriate position.
- Check the input voltage (for three-phase, check the line voltages of the input).
- Make sure all the environmental requirements are satisfied.

12-1 OPERATION AT NO LOAD

- After the above-mentioned checks have been completed, turn the power switch of the load off. When a power switch is not provided to the load, disconnect it.
- Turn the power switch (no-fuse breaker) of the regulator ON. The pilot lamp lights up and the instruments indicate the input or output voltage and the output current.
- When the output voltage deviates from the rated value, proceed as follows:

a. Wait at least 20 to 30 seconds after the regulator has been switched on.

b. Adjust the output voltage by turning the output voltage adjustor. For models for three-phase, adjust the line voltages of the output by turning the line voltage fine adjustors.

12-2 OPERATION WITH LOAD

After the output voltage is adjusted, turn the regulator OFF and connect the load again. Then, switch the regulator ON again.

Check the followings:

- Make sure the output voltage of the regulator is stabilized.
- Make sure the output current is less than the rated maximum current.
- Make sure no unusual noise is heard.

13 ROUTINE INSPECTION

The following inspection is recommended.

(1) At least every month

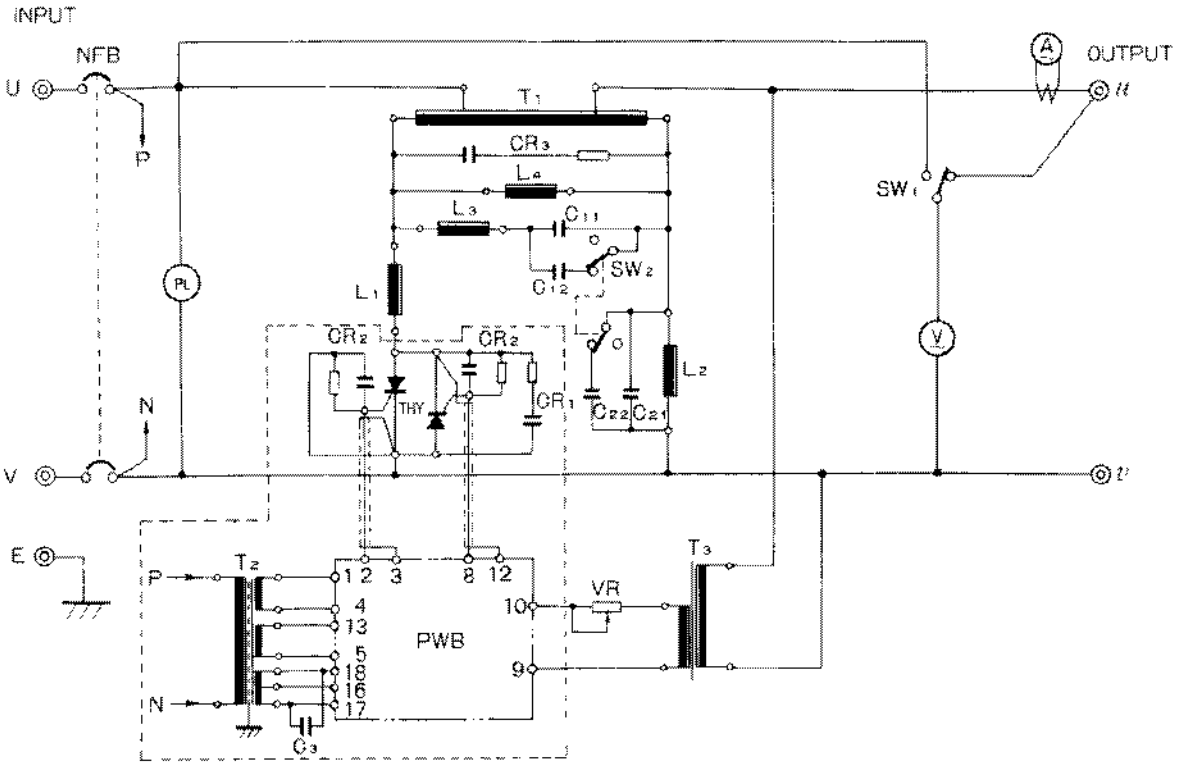
- Check whether the output voltage is stable.
- Check whether the output current is less than the rated maximum value.
- Check for unusual noise.
- Check for unusual smell.

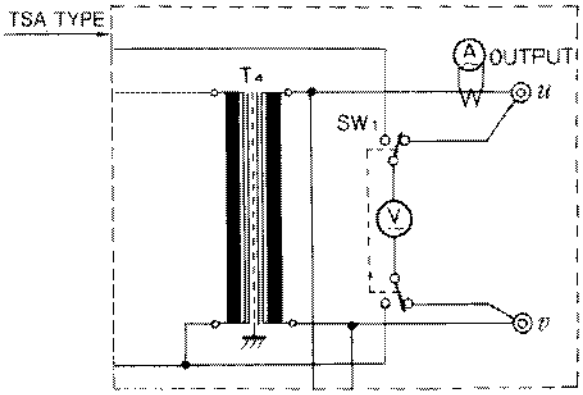
(2) Every three months to every year

- Check the cables for temperature rise.
- Check the terminals for loosen bolts.
- Check the inside of the regulator for dust, oily stains.
- Check the transformers and reactors for change of color.

14 MAIN CIRCUIT DIAGRAM

MODELS FOR SINGLE-PHASE (TA AND TSA)

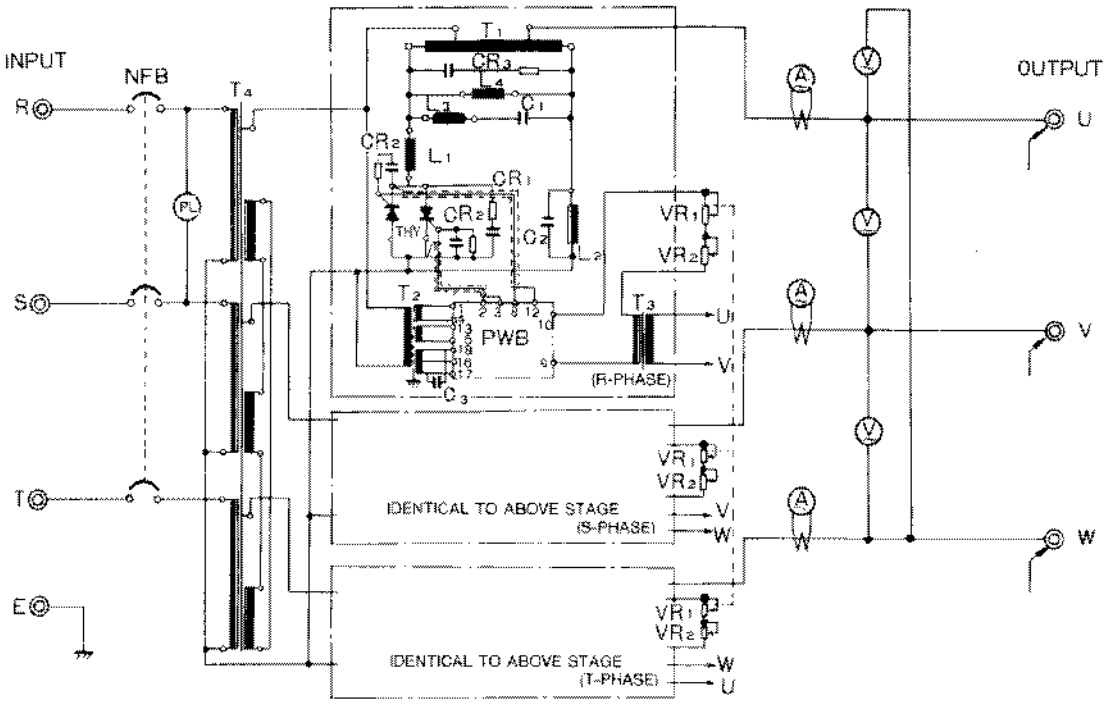


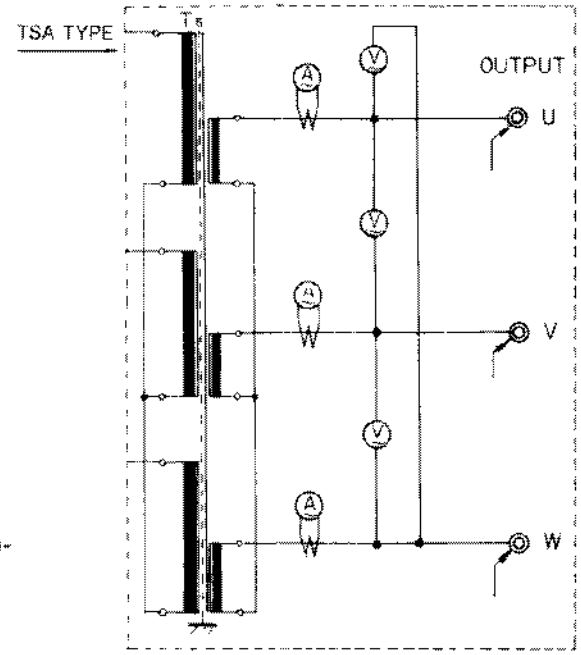


T1: Control reactor
T2: Control transformer
T3: Detecting transformer
T4: Main transformer
(isolated and electrostatically shielded)
L1: Series reactor
L2: Parallel reactor
L3, L4: Waveform compensating reactors
THY: Thyristor
C11, C12, C21, C22, C3:
Waveform compensating capacitors
CR1, CR2:
Protection circuits
CR3: Waveform compensating circuit
PWB: Deviation voltage detector and phase control circuit (Control circuit board)
VR: Output voltage adjustor
NFB: Power switch (No-fuse breaker)
PL: Pilot lamp
V: Voltmeter
A: Ammeter
SW1: Voltmeter function switch
SW2: Frequency selector

MAIN CIRCUIT DIAGRAM

MODELS FOR THREE-PHASE (TA AND TSA)





T_1: Control reactor
T_2: Control transformer
T_3: Detecting transformer
T_4: Input transformer
T_5: Main transformer
(isolated and electrostatically shielded)
L_1: Series reactor
L_2: Parallel reactor
L_3, L_4: Waveform compensating reactors
THY: Thyristor
C_1, C_2, C_3:
Waveform compensating capacitors
CR_1, CR_2:
Protection circuits
CR_3: Waveform compensating circuit
PWB: Deviation voltage detector and phase control circuit (Control circuit board)
VR_1: Output voltage adjustor
VR_2: Line voltage fine adjustor
NFB: Power switch (No-fuse breaker)
PL: Pilot lamp
V: Voltmeter
A: Ammeter

15 WIRING MATERIALS AND VOLTAGE DROP TABLE

D : diameter dV : Voltage drop(V/m)
De : diameter of the grounding cable

Model	Cable for input side				Cable for output side				De	Terminal & bolts		
	D	dV	D	dV	D	dV	D	dV		Input	Output	Grounding
TA-105	1.6φ	0.163	3.5mm²	0.059	1.6φ	0.089	2.0φ	0.057	2.0mm²	M 4	M 4	M 4
TA-1010	2.0φ	0.209	8	0.082	1.6φ	0.178	5.5mm²	0.065	2.0	M 4	M 4	M 4
TA-1015	5.5mm²	0.179	14	0.071	2.0φ	0.170	8	0.067	2.0	M 4	M 4	M 4
TA-1020	8	0.164	22	0.060	5.5mm²	0.130	14	0.051	3.5	M 5	M 5	M 5
TA-1030	14	0.125	30	0.058	8	0.134	22	0.049	3.5	M 5	M 5	M 5
TA-1050	22	0.132	50	0.058	14	0.128	30	0.060	5.5	M10	M 8	M 6
TA-1075	30	0.146	80	0.055	22	0.122	50	0.054	14	M12	M10	M 8
TA-10100	38	0.153	100	0.059	22	0.162	60	0.060	14	M12	M10	M 8
TA-10150	50	0.175	150	0.059	30	0.178	100	0.054	22	M16	M12	M10
TA-10200	60	0.194	200	0.059	38	0.188	125	0.057	22	50×6t	M16	M10
TA-10300	100	0.175	250	0.070	60	0.178	150	0.072	38	75×6t	50×6t	M12
TA-10400	150	0.155	325	0.072	80	0.178	200	0.072	50	100×6t	50×6t	M12
TA-10500	200	0.146	400	0.073	100	0.178	250	0.072	60	100×6t	75×6t	M12
TA-10750	250	0.175	500	0.088	150	0.178	400	0.067	80	100×12t	100×6t	M16
TA-101000	325	0.179	960	0.065	200	0.176	500	0.072	100	150×10t	150×6t	M16
TSA-10300-2	50	0.173	150	0.059	60	0.178	150	0.072	22	50×6t	50×6t	M10
TSA-10400-2	60	0.194	200	0.059	80	0.178	200	0.072	22	50×6t	50×6t	M10
TSA-10500-2	80	0.182	250	0.059	100	0.178	250	0.072	38	75×6t	75×6t	M12
TSA-10750-2	125	0.175	325	0.067	150	0.178	400	0.067	50	75×6t	100×6t	M12
TSA-101000-2	200	0.146	400	0.073	200	0.176	500	0.072	60	100×6t	150×6t	M12
TA-205	1.6φ	0.163	3.5mm²	0.060	1.6φ	0.089	2.0φ	0.057	2.0mm²	M 4	M 4	M 4
TA-207.5	2.0φ	0.157	8	0.062	1.6φ	0.133	5.5mm²	0.049	2.0	M 4	M 4	M 4
TA-2010	2.0φ	0.209	8	0.082	1.6φ	0.178	5.5	0.065	2.0	M 5	M 5	M 5
TA-2015	5.5mm²	0.159	14	0.063	2.0φ	0.170	8	0.067	2.0	M 5	M 5	M 5
TA-2025	8	0.182	22	0.066	5.5mm²	0.162	14	0.064	3.5	M 8	M 6	M 6
TA-2037.5	14	0.156	38	0.058	8	0.167	22	0.061	5.5	M 8	M 8	M 6
TA-2050	22	0.132	50	0.058	14	0.128	30	0.060	5.5	M10	M 8	M 6
TA-2075	30	0.146	80	0.055	22	0.122	50	0.054	14	M12	M10	M 8
TA-20100	38	0.153	100	0.059	22	0.162	60	0.060	14	M12	M10	M 8
TA-20150	50	0.173	150	0.059	30	0.178	100	0.054	22	M16	M12	M10
TA-20200	60	0.194	200	0.059	38	0.188	125	0.057	22	50×6t	M16	M10
TA-20250	80	0.182	250	0.059	50	0.178	150	0.060	38	50×6t	M16	M12
TA-20375	125	0.175	325	0.067	80	0.167	200	0.067	50	75×6t	50×6t	M12
TA-20500	200	0.146	400	0.073	100	0.178	250	0.072	60	100×6t	75×6t	M12
TA3-3	2.0φ	0.139	8mm²	0.055	1.6φ	0.133	5.5mm²	0.049	2.0mm²	M 6	M 6	M 6
TA3-5	5.5mm²	0.132	14	0.052	2.0φ	0.142	8	0.058	2.0	M 6	M 6	M 6
TA3-7.5	8	0.136	22	0.050	5.5mm²	0.122	14	0.048	3.5	M 8	M 6	M 6
TA3-10	14	0.104	30	0.049	8	0.112	22	0.041	3.5	M 8	M 6	M 6
TA3-15	14	0.156	38	0.057	14	0.096	30	0.045	5.5	M10	M 8	M 6
TA3-20	22	0.132	60	0.049	14	0.128	38	0.047	5.5	M10	M 8	M 6
TA3-30	30	0.145	80	0.055	22	0.122	50	0.054	14	M12	M10	M 8
TA3-40	38	0.153	125	0.047	30	0.110	80	0.045	14	M12	M12	M 8
TA3-50	50	0.145	150	0.049	38	0.117	100	0.045	22	M16	M12	M10
TA3-75	60	0.182	200	0.055	38	0.176	100	0.067	22	50×6t	M16	M10
TA3-100	100	0.145	250	0.058	60	0.149	150	0.060	38	75×6t	M16	M12
TA3-150	150	0.145	325	0.067	100	0.134	250	0.054	50	100×6t	75×6t	M12
TA3-200	200	0.145	500	0.058	125	0.142	325	0.055	60	100×12t	100×6t	M12

* TSA models except the models from TSA-10300-2 type to TSA-101000-2 type apply to all the TA model.

16 TROUBLE-SHOOTING

SYMPTOM	CAUSE (S)	REMEDY
No output voltage (Voltmeter indicates zero)	Power source disconnected	Connect power source
	Power switch turned OFF	Turn power switch ON
	Loosen terminal bolts	Tighten terminal bolts
	Defective voltmeter or pilot lamp	Replace defective voltmeter or pilot lamp
Incorrect output voltage	Improper output voltage adjustment	Turn output voltage adjustor
	Input voltage too low or too high	Use regulator at rated input voltage
	Bad contact between control circuit board and its socket	Remove and refit control circuit board
	Defective control circuit board	Repair or replace defective parts
	Defective detecting transformer	Repair or replace defective parts
	Defective output voltage adjustor	Repair or replace defective parts
	Defective line voltage fine adjustor (three-phase)	Repair or replace defective parts
	Defective thyristor	Repair or replace defective parts
	Line voltage of the output unbalanced	Adjust line voltages by turning line voltage fine adjustors
Hunting occurs	Frequency selector in wrong position	Turn frequency selector to correct position
	Periodic variation of input voltage at a certain frequency (Resonance occurs)	Check variation of input voltage
	Periodic variation of load at a certain frequency (Resonance occurs)	Disconnect load and check whether hunting stops or not
	Defective control circuit board	Repair or replace defective control circuit board
Power switch (no-fuse breaker) cannot be turned ON	Defective no-fuse breaker	Replace defective no-fuse breaker
	Short circuit between output terminals or overload	Operate regulator at rated load
	Burning transformer or reactor	Replace burning transformer or reactor
Unusual hum	Loosen screws securing transformer or reactor	Tighten loosen screws
Unusual smell	Burning transformer or reactor	Replace burning transformer or reactor

For any assistance please contact our engineering division (the address is given below), and inform us of the following.
● Model and serial numbers ● Fault conditions (in the case of problems) ● Operating conditions

INSPECTION CERTIFICATE

We hereby certify that this product has been duly passed our quality standard.

APPROVED BY	TESTED BY

Matsunaga Manufacturing Co., Ltd.

4-44, Tsunashima-nishi 5-chome, Kohoku-ku, Yokohama 223, Japan.
Phone : Yokohama 045-542-2121 Facsimile : Yokohama 045-542-2141
Telex : J36210 MATEX

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