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5100TEU CONTAINER VESSEL

MAIN SWITCHBOARD INSTRUCTION MANUAL

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|  TERASAKI <i>Ensuring Service, Maintaining Quality</i> | | TERASAKI (CHINA) ELECTRIC CO., LTD | |

ABOUT THIS MANUAL

This Main switchboard instruction manual is intended for trained competent person performing such work as maintenance and inspection of switchboards.

Be sure to read and observe safety notices not only in this manual but also on caution plates and warning plates affixed on the switchboard.

This instruction manual is made up of the following sections.

1. SAFETY PRECAUTIONS FOR THE SWITCHBOARD
2. INSTRUCTION MANUAL FOR MAIN SWITCHBOARD
2. GENERATING PLANT MANAGEMENT SYSTEM FOR MARINE USE
Model GAC21 INSTRUCTION MANUAL

Before reading the other sections of this manual, be sure to read and understand the safety measure explained in the next section, “SAFETY PRECAUTIONS FOR THE SWITCHBOARD ” .

Table of Contents

CHAPTER 1 GENERAL

| | |
|--|--------|
| 1. Introduction ----- | page 4 |
| 2. Generators ----- | page 4 |
| 3. Rules and Regulations ----- | page 4 |
| 4. Construction ----- | page 4 |
| 5. Molded Case Circuit Breakers ----- | page 5 |
| 6. Air Circuit Breakers ----- | page 5 |
| 7. Other Electric Constructions and Mechanical Constructions ----- | page 7 |

CHAPTER 2 RUNNING AND STOPPING OF GENERATORS

| | |
|--|---------|
| 1. Summary ----- | page 8 |
| 2. Manual Control of Diesel Generators ----- | page 13 |
| 2.1 Start Stop Control of Diesel Engine ----- | page 13 |
| 2.2 Start Stop Control of Diesel Generators ----- | page 16 |
| 2.2.1 Single Unit Operation ----- | page 16 |
| 2.2.2 Parallel Operation ----- | page 18 |
| 2.2.3 Stopping a Generator ----- | page 22 |
| 2.2.4 Automatic Load Shift Control ----- | page 23 |
| 4. Automatic Starting of Diesel Generators ----- | page 23 |
| 4.1 Summary ----- | page 23 |
| 4.2 Automatic Stand-by Connection on ACB Abnormal Trip ----- | page 26 |
| 4.2.1 One Generator in Service (Three Stand-bys) ----- | page 26 |
| 4.2.2 Two Generators in Service (Two Stand-by) ----- | page 26 |
| 4.2.3 Three Generators in Service (One Stand-by) ----- | page 27 |
| 4.3 Automatic Generator Replacement on Bus Abnormal ----- | page 27 |
| 4.3.1 One Generator in Service (Three Stand-bys) ----- | page 27 |
| 4.3.2 Two Generators in Service (Two Stand-by) ----- | page 27 |
| 4.3.3 Three Generators in Service (One Stand-by) ----- | page 28 |
| 4.4 Automatic Stand-by Start and Paralleling on Overload ----- | page 28 |
| 4.4.1 One Generator in Service (Three Stand-bys) ----- | page 28 |
| 4.4.2 Two Generators in Service (Two Stand-by) ----- | page 28 |
| 4.4.3 Three Generators in Service (One Stand-by) ----- | page 28 |
| 4.5 Power Management ----- | page 29 |
| 4.5.1 Automatic Start And Synchro Due To Heavy Load ----- | page 29 |
| 4.5.2 Automatic Load Shift and Stop Due To Light Load ----- | page 29 |
| 4.5.3 Large Motor Start Blocking Control ----- | page 29 |

CHAPTER 3 MISCELLANEOUS

| | |
|---|---------|
| 1. Monitoring of Insulation Level ----- | page 31 |
| 1.1 Summary ----- | page 31 |
| 1.2 Insulation Resistance Monitor ----- | page 31 |

| | |
|---|---------|
| 2. Preferential Tripping System ----- | page 31 |
| 3. Overload Protection of Generators ----- | page 32 |
| 4. ACB TROUBLE RESET Push-button Switch ----- | page 32 |
| 5. Trouble Alarm System for Main switchboard ----- | page 32 |
| 6. Switch of Control Power Source for Main Bus Bar and Disconnecting of Main bus bar Duplication ----- | page 33 |
| 7. Differential Protection----- | page 34 |

CHAPTER 1 GENERAL

1. Introduction

A main switchboard is an assembly of switching controls, regulating devices, measuring instruments, indicators and protective devices, and it serves as the switching center of the electrical distribution system for efficient centralized distribution control. This main switchboard distributes electric power to the various loads on board a ship. In the event of a fault in a load circuit, an appropriate protective device will operate to clear the fault in order to protect both the circuit and equipment and to maintain the continuity of service.

One or more of the generators mentioned in Section 2 are placed on the bus of this main switchboard as necessary to cover the total power demand, and the generator power is distributed to the individual feeder circuits from the feeder panels of the main switchboard. Generators are normally controlled in automatic or manual mode.

This Instruction manual covers the following items:

- MAIN SWITCHBOARD
- 220V FEEDER PANEL

2. Generators

| | |
|------------|------------------|
| Type: | Diesel Generator |
| Voltage: | 450V AC 3-phase |
| Capacity: | 1800KW |
| Frequency: | 60 Hz |
| Quantity: | 4 sets |

3. Rules and Regulations

This main switchboard designed and manufactured to the Rules and Regulation of the GL.

4. Construction

(1) Type

The main switchboard is a metal-enclosed type, having no live parts exposed on the outside surfaces.

(2) Framework

The main switchboard consists of a number of cells, and each cell is a rigidly formed, vibration-resistant, steel-sheet framework.

The front panel door of steel plate is hinged to one side of the framework, and has latching knobs on the other side as the fastening means.

These latching knobs are two kinds, one to turn 90 degree counter-clockwise to unfasten and open the front panel door for internal inspection, other knobs to slide to panel

door hinge side to unfasten and open the front panel door for internal inspection.

The panel door can be kept open by means of a stopper. The internal devices (circuit breakers, instrument potential and current transformers, relays and fuses, etc.) are reliably mounted to resist shocks and vibration and arranged for ready replacement from the switchboard front and rear.

(3) Insulating Material

Synthetic resin is used to insulate the bare live parts, and each insulator is specially shaped to endure the temperature, humidity and other environmental conditions without degradation of the electrical insulating properties over long periods of service.

5. Molded Case Circuit Breakers

All feeder circuit breakers are Molded Case Circuit Breakers, (hereafter referred to as "MCCB").

They will automatically trip if an overload or fault develops in their load circuitry, and the re-closing can be readily made by resetting the tripped breaker and without the need for element replacement such as fuses, ensuring high operational safety.

| CAUTION | Handling of a Molded Case Circuit Breaker |
|----------------|--|
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|--|
| <p>Details, such as maintenance and characteristics, an accessories function, etc. of a molded case circuit breaker, are separate volume "TemBreak MOLDED CASE CIRCUIT BREAKER OPERATION MANUAL "Please refer to instruction manual.</p> |
|--|

6. Air Circuit Breakers

Each AR series or AH series Air Circuit Breaker (hereafter referred to as "ACB") can be operated safely from the outside of the panel front.

| CAUTION | Handling of Air Circuit Breaker |
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|----------------|--|

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|---|
| <p>Details, such as maintenance and characteristics of an air circuit breaker and an accessory function, are separate volumes "TemPower 2 INSTRUCTION MANUAL FOR AIR CIRCUIT BREAKERS (for marine use) Types AR " Please refer to instruction manual.</p> |
|---|

Operation Methods

The AR series ACBs are available either in manual charging type or in motor charging type.

(1) Motor Charging Type

- a) Supply the specified control power voltage to the charging motor circuit. As soon as the closing springs are discharged, the charging motor is turned on to charge the closing springs.
- (b) The charging motor is automatically stopped when the closing springs are fully charged, and the spring charged indicator shows "CHARGED ". It will take not more than approx. 10 seconds to charge the closing springs depending on the rated operating voltage of the ACB type.
- (c) push "ACB CLOSE "button to close the ACB, or push "ACB OPEN " button to open the ACB.

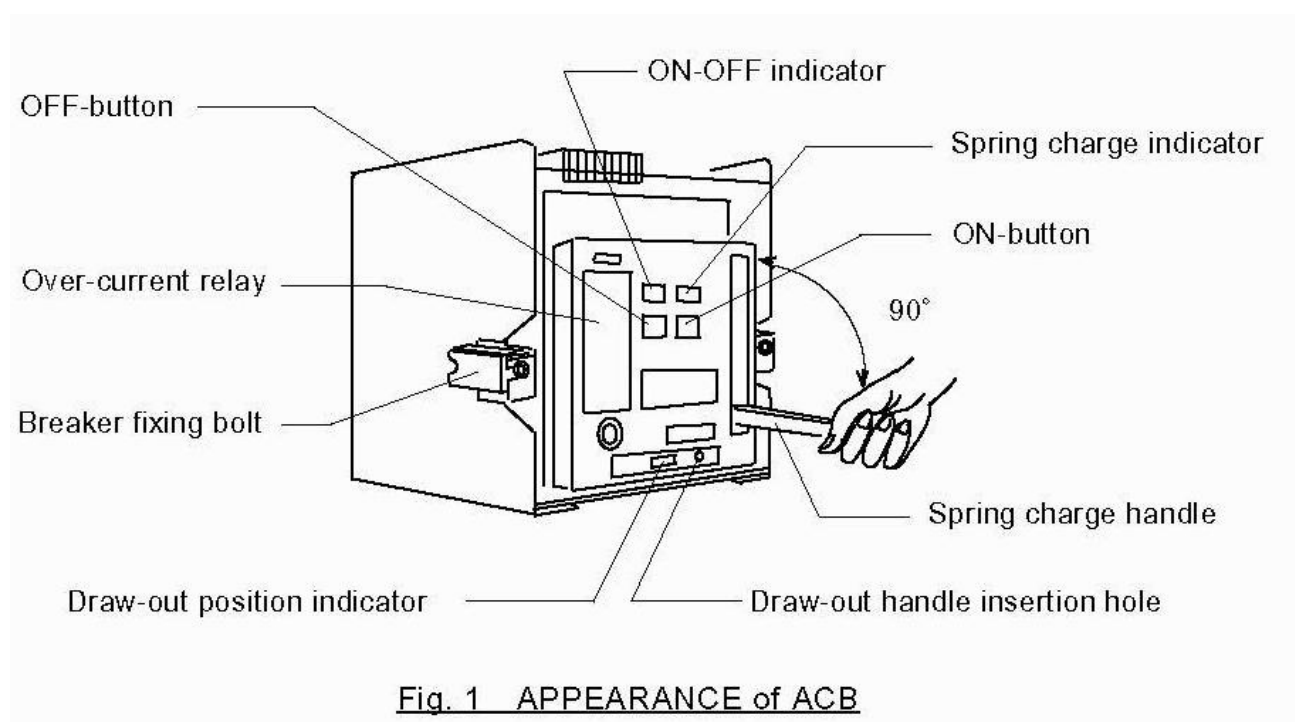


Fig. 1 APPEARANCE of ACB

(2) Manual Charging Type

- (a) Pumping the charging handle.
- (b) When the closing springs are fully charged, a metallic click will be heard and no further pumping of the charging handle will be possible. When the charging handle is pumped with its maximum stroke, about ten (10) to thirteen (13) pumping cycles will complete the charging. Check that the spring charged indicator now shows "CHARGED ".
- (c) Open the clear shutter upward and press the push-button "PUSH TO ON ". This releases the charged closing springs and the ACB is closed.
- (d) Open the clear shutter upward and press the push-button switch "PUSH TO OFF ". This tripping opened the ACB.

7. Other Electric Constructions and Mechanical Constructions

Refer to the “GENERAL SPECIFICATION SE ”of MAIN SWITCHBOARD finished drawing for the specification details of Electric construction and Mechanical construction.

CHAPTER 2 RUNNING AND STOPPING OF GENERATORS

1. Summary

The main bus of the main switchboard is served by up to four generators, driven by their respective diesel engines.

This generator automatic control system (GAC-UMS) is performed by a computerized generator automatic control functions “GENERATING PLANT MANAGEMENT SYSTEM GAC21” : generator voltage monitoring, bus voltage and frequency monitoring, generator synchronizing (Paralleling), load sharing control and load shift control.

The “GENERATING PLANT MANAGEMENT SYSTEM GAC21 ” has the following features:

The “Generating plant management system GAC21 ” (hereafter referred to as the **GAC21 system**.) is an extremely easy to use and highly reliable total system.

The “GAC21 system ” is composed of the one programmable controller Generating plant control device GAC21 (hereafter referred to as the **GAC21 Controller**.) And one of the DIGITAL SYNCHRONIZER FAS-113DG and each device are installed in switchboard under common section.

The “GAC21 system ” is responsible for overall management of the generating plant. It has an automatic synchronizing/automatic load sharing function, automatic generator start and changeover commands, and power management functions. It is used to automate plants with unattended machinery rooms and performs efficient power management for super-rationalization plants.

The “GAC21 system ” always monitors both the data transmission system and the operation of the GAC21 Controller.

System design based on two principles; “manual control should override automatic control ” and “control system should be isolated or separated from safety and protective systems, alarm systems and other important systems ” , so that the safety of the ship's electric power system and the ship herself will be secured even if the worst happens to the GAC21 system.

The “GAC21 system ” controls generating plant centralized so that extremely high level of power supply reliability is achieved.

Handling of Generating Plant Management **CAUTION** System GAC21

The details of GAC21 system are the instruction manuals of a separate volume.

“GENERATING PLANT MANAGEMENT SYSTEM FOR MARINE USE **Model GAC21 INSTRUCTION MANUAL** ” Please refer to the volume the PART 1 to PART 3, and on the PART 4.

In addition, refer to “GAC21 & CONNECTOR ASSIGNMENT (COMMON) **S12-2** ” of the main switchboard finished drawing for the composition and arrangement of each module.

In this ship, additional equipment of the one “Digital Input/output module

NP1W1606T ” is carried out to the composition and arrangement of a module given in an instruction manual “GENERATING PLANT MANAGEMENT SYSTEM FOR MARINE USE **Model GAC21** INSTRUCTION MANUAL ” .
 In addition, Refer to “GAC21 SETTING LIST **GA11/ GA12** ” of the main switchboard finished drawing for the various kinds of control setting value.

The “FAS-113DG DIGITAL SYNCHRONIZER ” has the following features:

The “Digital Synchronizer ” (hereafter referred to as FAS-113DG **DEVICE**.) is a small, lightweight unit using a one-chip CPU.

In addition, the use of programmed control allows for flexibly performing synchronous closing control and synchronous detection control.

Both the “Automatic synchronizing function ” and “Check synchronizing function ” are available, but GAC21 system used for “Automatic synchronizing function ” .

CAUTION Handling of Digital Synchronizer

The automatic synchronous closing control function for a generator, as mentioned in the instruction manual for the “GENERATING PLANT MANAGEMENT SYSTEM FOR MARINE USE **Model GAC21** INSTRUCTION MANUAL ” is independent from the “GAC21 CONTROLLER ” .
 For further information on this function, refer to the instruction manual for the “DIGITAL SYNCHRONIZER TYPE FAS-113DG INSTRUCTION MANUAL ” .

GAC21 SYSTEM CONTROL FUNCTIONS

- * CONTROL MODE SELECTION (AUTO-MANU)
- * ACB INDIVIDUAL CLOSE/OPEN
- * GENERATOR ENGINE START/STOP CONTROL ----- * 1
- * GOVERNOR MOTOR CONTROL (FREQUENCY/OUT PUT CONTROL)
- * FREQUENCY CONSTANT CONTROL IN GENERATOR SINGLE OPERATION
- * GENERATOR VOLTAGE DETECTION (ESTABLISHMENT)
- * GENERATOR ACTIVE POWER DETECTION
- * ACB NON-CLOSE DETECTION ----- * 2
- * ACB ABNORMAL TRIP DETECTION
- * AUTOMATIC PROPORTIONAL LOAD SHARING CONTROL & FREQUENCY CONTROL IN GENERATOR PARALLEL OPERATION
- * PREFERENTIAL TRIP (ACB ABNORMAL TRIP)
- * AUTOMATIC SYNCHRONIZING CONTROL/SYNCHRONIZING FAIL DETECTION ----- * 3

- * AUTOMATIC LOAD SHIFT and ACB TRIP CONTROL
- * AUTOMATIC STANDBY START AND ACB CLOSE
- * AUTOMATIC START/STOP ORDER SELECTION
- * BUS VOLTAGE MONITOR (HIGH/LOW)
- * BUS FREQUENCY MONITOR (HIGH/LOW)
- * ALARM INDICATOR LAMP OUTPUT FOR GENERATOR
- * INDICATOR LAMP OUTPUT FOR GENERATOR
- * ALARM INDICATOR LAMP OUTPUT FOR COMMON USE
- * INDICATOR LAMP OUTPUT FOR COMMON USE
- * TOTAL POWER, SURPLUS POWER MONITOR AND DETECTION
- * SETTING DEVICE OPERATION ----- * 4
- * SELF-DIAGNOSTICS FUNCTIONS

Remarks:

- * 1 : The GAC21 System not execute the engine control, engine control perform other engine control device.
- * 2 : ACB non closure includes those due to auto synchronizing fail, individual closing failure and voltage non establishment.
- * 3 : The automatic synchronous closing control or check synchronizing control is performed by the FAS-113DG DEVICE.
However the GAC21 CONTROLLER detects an automatic synchronous failure.
- * 4 : The display unit means the HT21-001 LED SETTING DEVICE.

An operation mode for each generator can be selected via the OPERATION MODULE (hereafter referred to as OP Module) provided on each generator panel.

The OP Module also enables you to semi-automatic control and manual start/stop of generator engine and monitors its operation.

The following figures and CAUTION tables show the OP MODULE SPECIFICATIONS for operations, indications, and other.

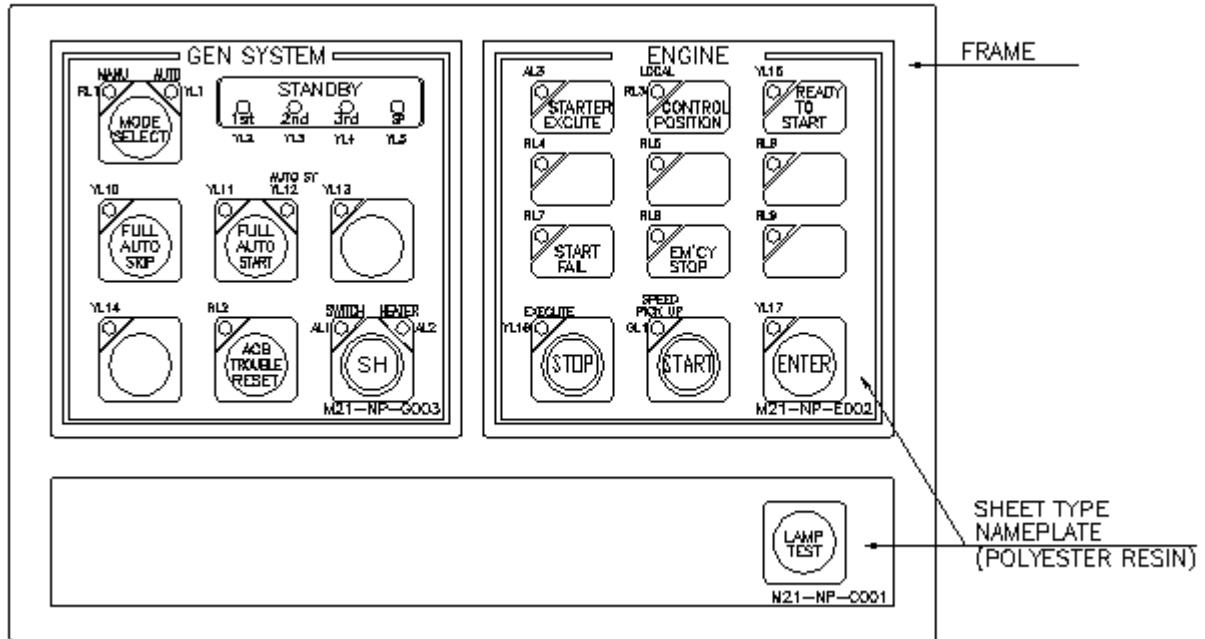


Fig. 2 SPECIFICATION OF OP MODULE

CAUTION Operation Module of Generator Panels

The OP Module mounted switches and LED indicator lamps:

1. GENERATOR SYSTEM group

- (1) Generator control MODE SELECT push-button switch with MANU (RL1) and AUTO (YL1) indicator lamp.
- (2) STANDBY indicator lamp: 1st (YL2), 2nd (YL3),3rd (YL4).
- (3) FULL AUTO STOP push-button switch with indicator lamp (YL10).
- (4) FULL AUTO START push-button switch with indicator lamp (YL11).
- (5) ACB TROUBLE RESET push-button switch with indicator lamp (RL2).
- (6) Space heater SH push-button switch with closed SWITCH indicator lamp (AL1) and HEATER activate indicator lamp (AL2).

2. ENGINE control group

- (1) Engine START push-button switch with SPEED PICK UP indicator lamp (GL1).
- (2) Engine STOP push-button switch with EXECUTE indicator lamp (YL16).
- (3) Engine start/stop ENTER push-button switch with indicator lamp (YL17).
- (4) LED Indicator lamps
 - a) STARTER EXCUTE indicator lamp (AL3).
 - b) CONTROL POSITION LOCAL indicator lamp (RL3).
 - c) READY TO START indicator lamp (YL15).
 - d) START FAIL indicator lamp (RL7).
 - e) EM'CY STOP indicator lamp (RL8). --- Turned on by the d) e) f) or g) above.

3. COMMON section group

- (1) EM'CY STOP SOURCE indicator lamp (AL4).
- (2) SHORE power ON indicator lamp (AL5).
- (3) DC24V SOURCE indicator lamp (YL19).
- (4) EM'CY GEN STANDBY (YL20)
- (5) EM'CY GEN RUN (GL2)
- (6) LAMP TEST push-button switch.

Notes:

LED indicator lamps.

- a. Color: YL --- YELLOW, RL --- RED, GL --- GREEN, AL --- AMBER..
- b. The symbols such as YL1, RL1, GL1 and AL1 etc. are not indicated on the OP Module sheet.

2. Manual Control of Diesel Generators

2.1 Start Stop Control of Diesel Engine --- (FC11) (FC12) (FC14)

Start-stop control of each diesel generator engine may be made remotely from the Main switchboard (MSB).

The latter has a “CONTROL POSITION ” select switch (COS-L) on the machine side (M/S) to prevent the simultaneous control from both control positions.

The above select switch “CONTROL POSITION ” selected two positions, one of the “LOCAL ” (machine side operation) and other position “REMOTE ” (main switchboard operation).

If the control position is M/S, the CONTROL POSITION “LOCAL (RL3)” indicator lamp on the OP Module is turned ON and control position “REMOTE ” the indicator lamp “LOCAL (RL3)” turned OFF.

However, control and operation of generators engine in semi-automatic mode can be done via the Main switchboard (MSB). For further details, refer to the Chapter 2, section 3, “Semi-automatic Control of Diesel Generators ” .

(1) For remote Diesel generator engine (hereafter referred to as the 「 Diesel engine 」) control from the main switchboard, the following conditions must be satisfied:

- 1) 24V DC control power is supplied and the “DC24V SOURCE (YL19)” indicator lamp on the OP Module is turned on.
- 2) The alarm and trouble indicator lamp is turned off.
- 3) The “CONTROL POSITION ” select switch (COS-L) on the machine side is set to “REMOTE ” position and the “READY TO START (YL15)” indicator lamp on the OP Module is turned on to indicate this switch setting.
- 4) Press the “MODE SELECT ” push-button switch on the OP Module is set to “MANU ” position and “MANU (RL1)” indicator lamp is turned on.

CAUTION Selecting an Operation mode for Controlling Generator (1/2)

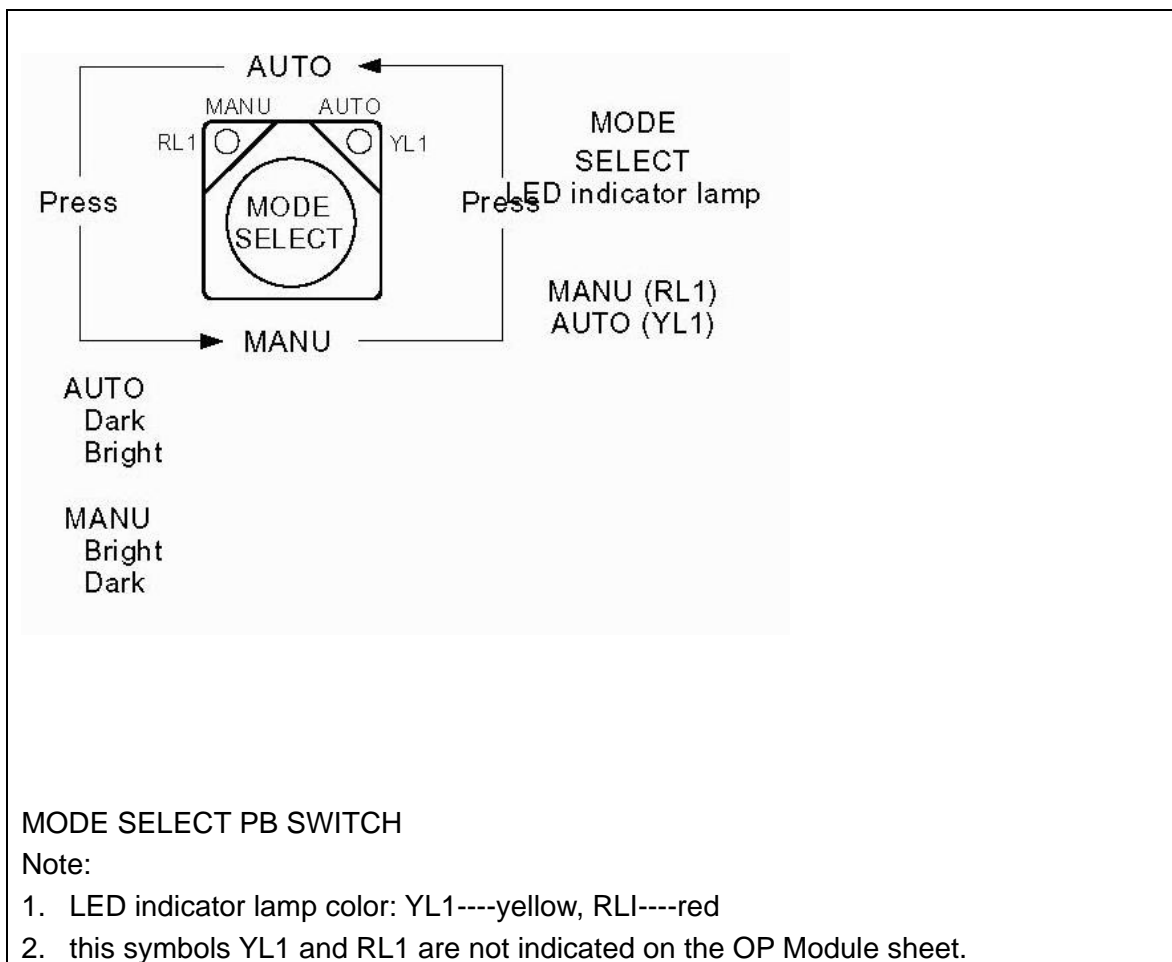
The “MODE SELECT ” push-button switch with LED indicator lamp is located on the OP Module on the each generator panel.

This push-button switch alternately between “MANU ” and “AUTO ” position, causing the corresponding LED indicators to start bright or dark according to the respective positions.

Note : (FC ××) --- Flowchart number

(Flowchart of the main switchboard finished-drawing side is referred to.)

CAUTION Selecting an Operation mode for Controlling Generator



CAUTION operation of generator engine start/stop control from MSB Operation Module

The generator engine start/stop operation method;

(On the MSB each generator panel)

1. Pay attention to START operation

The diesel engine start condition is satisfactory in accordance with (1) of 2.1

[Start Stop Control of Diesel Engine] of this chapter.

- 1) Press the START push-button switch and confirm the lighting of the ENTER indicator lamp (YL17) on the ENTER push-button switch.
- 2) Press the ENTER push-button switch within about 3 seconds.
(About 3 seconds after ward START operation resetting automatically.)
- 3) The SPEED PICK UP indicator lamp (GL1) on the START push-button switch is turned on after the engine low speed pick up.

2. Pay attention to STOP operation

- 1) Press the STOP push-button switch. Confirm the lighting of the ENTER indicator lamp (YL17) on the ENTER push-button switch.
- 2) Press the ENTER push-button switch within about 3 seconds.

(About 3 seconds after ward STOP operation resetting automatically.)

- 3) The EXECUTE indicator lamp (YL16) on the STOP push-button switch is turned on and engine stop execution, then engine stop and EXECUTE indicator lamp (YL16) is turned off.
- 4) The SPEED PICK UP indicator lamp (GL1) is turn off after the engine speed below rated RPM.

Notes :

- 1) LED indicator lamp color: YL16, YL17 --- YELLOW, GL1 --- GREEN.
- 2) The symbols such as YL1, RL1 etc. are not indicated on the OP Module sheet.

(a) Start Control

Check that the above preparation for starting the generator engine has been made satisfactory.

Start operation, press the “START ” and next to the “ENTER ” push-button switches located on the OP Module. The diesel engine will be started.

If the diesel engine does not reach the predetermined speed within 20 seconds of this start command, the START FAIL signal will be produced.

This signal cancels the start command signal and, at the same time, causes operation of the diesel engine stop control circuit.

By which the diesel engine is stopped and the alarm indicator lamp “START FAIL (RL7)” on the OP Module and “START FAIL ” indicator LCD on the is turned

(b) Stop Control

The stop operation of a diesel engine, Press the “STOP ” and next to the “ENTER ” push-button switches located on the OP Module to stop the diesel engine, after the generator is removed from the MSB bus.

(2) For diesel engine control from the Machine Side (M/S):

CAUTION Diesel Generator Engine Machine side Control

For machine side control details, refer to the generator diesel engine manufacturer's instruction manual.

2.2 Start Stop Control of Diesel Generators

Control of a diesel generator is performed from a Main switchboard (MSB).

Preparations Required --- (FC11)

- 1) The diesel generator ACB is open.
- 2) The manual voltage regulator (VR) for diesel generator is set to specified position.

| |
|---|
| CAUTION Manual Voltage Regulator Adjustment |
| For details of the manual voltage adjustments, refer to the diesel generator manufacturer's manual. |

- 3) 24V DC control power is supplied and the “DC24V SOURCE (YL19)” indicator lamp on the OP Module is turned on.
- 4) The alarm and trouble indicator lamp is turned off.
- 5) The “CONTROL POSITION ” select switch (COS-L) on the machine side is set to “REMOTE ” position and the “READY TO START (YL15)” indicator lamp on the MSB is turned on to indicate this switch setting.
- 6) Press the “MODE SELECT ” push-button switch on the OP Module is set to “MANU ” position and “MANU (RL1)” indicator lamp is turned on.

2.2.1 Single Unit Operation --- (FC12)

The following describes, as an example, steps to place No.1 diesel generator onto a dead bus.

(1) Engine Start

Start the diesel engine for No.1 diesel generator from the MSB in accordance with “2.1 Start-Stop Control of Diesel Engine ” of this chapter.

(2) Voltage Establishment

As the diesel engine accelerates to synchronous speed, the generator voltage will build up and the “GEN RUN ” indicator lamp on the No.1 generator panel will be turned on and the “READY TO START (YL15)” indicator lamp on OP Module is turned off.

(3) Voltage and Frequency Check and Adjustment

Check if the required generator voltage and frequency is reached with the voltmeter and frequency meter for No.1 generator panel, operating the “FREQUENCY & VOLTMETER ” switch (FVS-1) on the No.1 generator panel is set to each phase-to-phase position.

If the generator voltage is other than specified, adjust it with the manual voltage regulator controls.

If the frequency is higher than the rated value, turn the “GOVERNOR MOTOR ” control switch (GCS) to “LOWER ” position to decrease the generator frequency and adjust it to the rated value. If the frequency is lower than the rated value, adjust it to the rated value by setting the “GOVERNOR MOTOR ” control switch to “RAISE ” position.

(4) Feeding to Loads

Set the “FREQUENCY & VOLTMETER ” switch (FVS-2) on the Synchro. panel to “BUS ” position and read the bus voltage by double display voltmeter for Synchro. panel, the bus voltage should be zero.

On confirmation of this, push “ACB CLOSE ” button on the Synchro. panel to place No.1 diesel generator onto a dead bus.

After confirming that the bus is now energized to the rated generator voltage. Turn on the necessary feeder circuit breakers.

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| CAUTION Closing of Generator Air Circuit Breaker |
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| When the voltage applied to the main bus is supplied by the shore power source, Open the shore power supply MCCB to remove voltage from the main bus before closing the generator ACB. |
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|---|
| Interlock is provided that will prevent the generator ACB from closing if shore powers supply MCCB is closed. |
|---|

(5) Automatic Frequency Control

When the “MODE SELECT ” push-button switch setting from “MANU ” to the “AUTO ” position after closing the ACB of the No.1 diesel generator to provide connection to the bus enables the generator to under go automatic frequency control.

As soon as the generator is put on line with its ACB closed, the GAC21 Controller automatically controls the generator frequency through the governor motor control to maintain the bus frequency at the rated value.

The GAC21 Controller proper is located inside of the switchboard under common space.

Manual operation of the “GOVERNOR MOTOR ” control switch can override this automatic frequency control, but releasing the control switch restores the automatic frequency control.

(6) Manual Frequency Control

On closure of the generator ACB onto the bus, the generator frequency is automatically controlled to 60Hz constant by the automatic frequency control function of GAC21 Controller. You can override this automatic frequency control function for manual frequency control by positioning “MODE SELECT ” push-button switch on the No.1 generator panel is set to “MANU ” position.

This switch, when in “MANU ” position, de-energizes the governor drive output relay circuit of GAC21 Controller and enables you to control the generator frequency with “GOVERNOR MOTOR ” control switch to the desired frequency. Then, adjust the bus frequency to the rated value as necessary by operating No.1's “GOVERNOR MOTOR ” control switch to “LOWER ” or to “RAISE ” .

2.2.2 Parallel Operation --- (FC13) (FC32)

CAUTION Conditions for Generator Paralleling

To place a generator onto a live bus served by another generator at least the following three conditions must be satisfied:

- 1) The incoming generator voltage is approximately equal to the bus voltage.
- 2) The incoming generator frequency is approximately equal to the bus frequency.
- 3) The circuit breaker (ACB) for the incoming generator must be closed at an exact instant when the generator voltage is in phase with the bus voltage.

The following describes, as an example, steps to place No.2 diesel generator onto a live bus served by No.1 diesel generator.

(1) Engine Start

Start the diesel engine for No.2 diesel generator from the MSB in accordance with “2.1 Start-Stop Control of Diesel Engine ” of this chapter, and let No.2 diesel generator voltage establish.

(2) Voltage and Frequency Check and Adjustment

Set the “FREQUENCY & VOLTMETER ” switch (FVS-2) on the Synchro. Panel to compare the generator voltage with the bus voltage by double display voltmeter and compare the generator frequency with the bus frequency is shown in double display frequency meter. If they are not equal, adjust the generator voltage/frequency to the bus voltage/frequency (assumed to be the rated value).

(3) Closing the Generator ACB at Manual Synchronism

CAUTION Synchronous Closing Operation

To close the generator ACB while voltage is applied to the main bus, be sure to perform synchronous closing operation.
Closing the ACB without synchronization may cause abnormal tripping of the ACB.

The generator frequency is to be made slightly higher than the bus frequency in this step and next step.

The No.2 generator panel is furnished with synchroscope/ synchronization check lamp (with three lamps) and “ SYNCHRO. SELECT ” switch (SYS) to enable manual synchronous closing of the ACB in case that GAC21 Controller stops or fails to operate.

Next, set the “SYNCHRO. SELECT ” switch to “G2 ” position and observe the movement of the synchroscope pointer as well as the brilliance change of the synchronization check lamps (hereafter referred to as 「 synchro lamp 」).

(a) The synchroscope pointer rotates in FAST (clockwise) direction.

This condition indicates that the generator frequency (No.2 diesel generator's) is higher than the bus frequency (No.1 diesel generator's). The sequence of brilliance change of the three-synchro lamps is also in a clockwise direction.

In this case, set the “GOVERNOR MOTOR ” control switch for No.2 diesel generator to “LOWER ” until the synchroscope pointer change its direction of rotation from FAST to SLOW.

(b) The synchroscope pointer rotates in SLOW (counter-clockwise) direction.

This condition indicates that the generator frequency is lower than the bus frequency. The sequence of brilliance change of the synchro lamps is also in a counter-clockwise direction.

In this case, set the “GOVERNOR MOTOR ” control switch for No.2 diesel generator to “RAISE ” until the synchroscope pointer changes its direction of rotation from SLOW to FAST.

(c) The synchroscope pointer is stationary.

This condition indicates that the generator frequency is exactly equal to the bus frequency, and the position of the stationary pointer indicates the relative phase angle between the generator and bus voltage.

There is no brilliance change in the synchro lamps. In this case, set the “GOVERNOR MOTOR ” control switch for No.2 diesel generator to “RAISE ” until the synchroscope pointer starts to rotate in FAST direction.

(d) The synchroscope pointer points to 12 o'clock position.

Whether the pointer is moving slowly or stationary, this condition indicates that the generator voltage is in phase with the bus voltage (synchronism). At this instant, the middle top synchro lamp is completely dark and the two lower outside lamps are turned on at the same brightness.

(e) Closing the Generator ACB at Synchronism

CAUTION Manual Synchronous Closing Operation

Do not close the generator ACB unless it synchronizes point with the generator:

- a) Close the generator ACB within range of approximately 15 β on both the FAST side and the SLOW side, with the synchroscope pointer synchronization point as the 12 o'clock position.
 - b) ACB synchronous closing operation outside the range described in item a) above may pull the generator out of synchronism and cause abnormal tripping of the ACB.
- ACB abnormal tripping may result in no voltage on the main bus.

Observing the synchroscope / synchro lamp and operating the “GOVERNOR MOTOR ” control switch for No.2 diesel generator to the “RAISE ” position and adjust the frequency of the No.2 diesel generator so that it exceeds the bus frequency by 0.5 to 1.0Hz. Then gradually lower the generator frequency until the synchroscope pointer should rotate in FAST direction and complete one rotation in 3 to 4 seconds and synchronization check lamp flickers at intervals of 3 to 4 seconds, (This will result in the difference between bus and generator frequencies being approximately 0.3Hz).

Timing the closure of No.2 diesel generator ACB to occur at the exact instant of synchronism. push “ACB CLOSE ” button for No.2 diesel generator a little prior to the synchronism.

On closure of the No.2 diesel generator ACB, after the “SYNCHRO. SELECT ” switch turn to “OFF ” position. When two generators are on line, you must operate their “GOVERNOR MOTOR ” control switches simultaneously to “RAISE ” (frequency up) or to “LOWER ” (frequency down), operation of only one switch transfers load from one generator to the other rather than changing the frequency.

(4) Automatic Load Sharing Control

When the ACB for the No.2 diesel generator is closed while the “MODE SELECT ” switch for both the No.1 and No.2 diesel generators is in “AUTO ” position, the automatic load sharing function of GAC21 Controller controls the loads on both the generator to be identical, and ensures the rated frequency of the generators.

As soon as No.2 diesel generator is put on line, the GAC21 Controller's automatic load sharing control function starts to control the governor motors of No.1 and No.2 diesel generators, so that each generator will be loaded to the same percentage in reference to their rated kW output values and that the bus frequency will be maintained at the rated value.

Although the generator watt meters on the each generator panel indicate the kW load values on the respective generators.

Their loading kW is displayed on the LED screen of the handy type SETTING DEVICE.

For details see the PART 3 “Setting Value Display Functions ” of “GENERATING PLANT MANAGEMENT SYSTEM FOR MARINE USE **Model GAC21** INSTRUCTION MANUAL ” .

(5) Manual Load Sharing Control and Load Shift Control --- (FC14)

Normally, the load sharing control is automatically performed as mentioned in step (4) above. The load shift control is also performed automatically on a manual initiation as mentioned in Section 3.3 below.

In this case, “MODE SELECT ” push-button switch of No. 1 and No. 2 diesel generator on MSB is set as “MANU ” position.

(a) Manual Load Sharing Control

After No.2 diesel generator is placed onto a live bus served by No.1 diesel generator, set the “GOVERNOR MOTOR ” control switch for No.2 diesel generator to “RAISE ” so that No.2 diesel generator will take on kW load.

This lightens the kW load on No.1 diesel generator and increases the bus frequency, provided the total kW load remains unchanged during the control.

Therefore, it will be necessary to set the “GOVERNOR MOTOR ” control switch for No.1 diesel generator to “LOWER ” . It is recommended to operate the “GOVERNOR MOTOR ” control switches for No.1 and No.2 diesel generators simultaneously as mentioned for the purposes of both speedier load sharing control and bus frequency control. No.1 and No.2 diesel generators are to be equally loaded by this control.

The load division between No.1 and No.2 diesel generators, once determined, will remain unchanged, but the bus frequency will change if the total kW load is changed. In this case, the bus frequency is to be controlled by simultaneous operation of the both generators' “GOVERNOR MOTOR ” control switches to “RAISE ” (frequency up) if the bus frequency is lower than the rated value, or to “LOWER ” (frequency down) if the bus frequency is higher than the rated value.

When two or more generators are on line, you must operate their “GOVERNOR MOTOR ” control switches simultaneously to “RAISE ” or to “LOWER ” , operation of only one switch transfers load from one generator to the other rather than changing the frequency.

(b) Manual Load Shift Control

The following describes, as an example, the case where No.1 diesel generator is removed from the bus when No.1 and No.2 diesel generators are on line.

Set the No.1's “GOVERNOR MOTOR ” control switch to “LOWER ” and No.2's to “RAISE ” . This lightens the kW load on No.1 diesel generator and increases the kW load on No.2 diesel generator i.e., load on No.1 diesel generator is shifted to No.2 diesel generator.

When the load on No.1 diesel generator is reduced to about 5% of its rated kW output, push the No.1's “ACB OPEN ” button to remove No.1 diesel generator from the bus. Then, adjust the bus frequency to the rated value as necessary by operating

No.2's "GOVERNOR MOTOR " control switch to "LOWER " or to "RAISE " .

CAUTION Manual Load Sharing and Load Shift Control

- 1) Pay attention to variations of the bus frequency during the load sharing control or load shift control, and take the necessary action to maintain the bus frequency at the rated value.
- 2) Pay attention to the kW load on the generator to remain on line during the load shift control, and restore the original parallel operation if the generator to remain online is expected to be over loaded.
- 3) If the kW load on the generator to be removed is reduced beyond zero during the load shift control, the reverse power protection function will operate to trip the generator ACB.

2.2.3 Stopping a Generator --- (FC22)

The generator diesel engine stop control is performed in main switchboard (MSB) or machine side (M/S), no matter whether the "CONTROL POSITION " select switch (COS-L) on the machine side is in the "LOCAL " position or "REMOTE " position. Stop the diesel generator after it has been removed from the bus as follows:

- (1) When the diesel generator is in single unit operation, remove the unnecessary loads to lighten the load on the generator.
- (2) push "ACB OPEN" button to move the diesel generator from the bus.
- (3) When the generator is in parallel operation with another generator, perform step (5) (b) "Manual Load Shift Control " of Section 2.2.2. For automatic load shift control, refer to 3.3 of Section 3 this chapter.
- (4) The diesel engine stop operation (Press the "STOP " and next to the "ENTER " push-button switches) on the OP Module to stop the diesel engine, after the generator is removed from the MSB bus.

The diesel engine may be stopped on the machine side (LOCAL).

CAUTION Generator ACB Abnormal Tripping Occurrence

Manual stop or abnormal stop of the generator diesel engine with the generator ACB closed will result in abnormal tripping of the generator ACB.

2.2.4 Automatic Load Shift Control --- (FC32)

In order to remove one of the generators in parallel operation, the load on that generator is first shifted to the other generator(s) until it is reduced to nearly zero kW, then the generator is removed from the bus.

The following describes, as an example, the case where No.1 diesel generator (No.1 D/G) is removed when No.1 D/G and No.2 diesel generator (No.2 D/G) are in parallel operation.

Preparations Required

The “MODE SELECT ” switch on the OP Module each diesel generator is set to “AUTO ” position and indicator lamp “AUTO (YL1)” is turned on.

Press the push-button switch “AUTO STOP (YL10)” on the OP Module for No.1 D/G. The indicator lamp “AUTO STOP (YL10)” with the push-button switch will be light up and the GAC21 Controller automatic load control function starts its operation.

The start of the automatic load shift control function, which control the governor motors of No.1 D/G and No.2 D/G to shift the load on No.1 D/G to No.2 D/G.

When the load on No.1 D/G is reduced to about 5% of its rated kW output, the No.1 D/G ACB trip command signal is produced to remove No.1 D/G from the bus, and same time the “AUTO STOP (YL10)” indicator lamp with the push-button switch for No.1 D/G is turned off.

CAUTION Automatic Load Shift Control Discontinue

If the load on the generator to remain on line (No.2 D/G in the above example) is expected to reach 90% or more of its rated kW output as a result of automatic load shift control, press the push-button switch “AUTO LOAD SHIFT ” has no effect.

4. Automatic Starting of Diesel Generators

4.1 Summary

The bus voltage and frequency during the service are monitored by the GAC21 system bus monitoring function, and abnormal tripping of the generator ACB and trouble or delay in generator control before the generator is put on line are monitored by the GAC21 system generator monitoring function.

The four diesel generators (No.1 D/G, No.2 D/G , No.3 D/G and No.4 D/G) can be set as stand-bys when one or two or three generator is in service.

If abnormalities occur in the busbar under power supply, or a generator, a stand-by generator will be started automatically and the change to a stand-by generator will be automatically performed from the generator under operation. Should the 1st stand-by fail to start or its ACB fail to close, then the 2nd stand-by will be automatically controlled to replace 1st stand-by. And should this current 1st stand-by(the 2nd stand-by) fail to start or its ACB fail to close, then the 3rd stand-by will be automatically controlled to replace

1st stand-by.

The stand-by will also be automatically started when two or three generators in service is one generator ACB abnormal trip or generator in service is overloaded, in which case the started stand-by is automatically paralleled to service generator.

Footnotes:

- 1) The ACB abnormal trip refers to an automatic opening of the generator ACB other than by operation of the “ACB OPEN ” button or as a result of the automatic load shift control for 3.3 of section 3 this chapter.

An ACB abnormal trip may result from one of the following:

- Generator diesel engine emergency trip/manual stop
- Over-current (including a short-circuit fault)
- Under-voltage
- Reverse power flow
- Mechanical trouble of ACB itself

- 2) The ACB NON-CLOSE means one of the following conditions:

(a) ACB NON-CLOSURE

The stand-by generator's ACB does not close within 3 seconds of the ACB close command signal.

(b) VOLTAGE NON-ESTABLISHED

The voltage of the stand-by generator does not reach 95% of the rated value within 20 seconds after its diesel engine speed has reached a predetermined value.

(c) AUTOMATIC SYNCHRONIZING FAILURE

The automatic synchronizing (generator synchronizing and its ACB closure at synchronism) is not completed within 60 seconds of the auto synchro start command signal.

3) START FAILURE

The START FAILURE means a condition that after the start command signal is given the diesel engine speed of a diesel generator does not reach a predetermined value within 20 seconds.

(C) Preparations Required

The diesel generators (No.1 D/G, No.2 D/G , No.3 D/G and No.4 D/G) can be set as automatic starting stand-bys.

The following are conditions for a diesel generator to be set as a stand-by:

- 1) 24V DC control power is supplied and the “DC24V SOURCE (YL19)” indicator lamp on the OP Module is turned on.
- 2) The “Alarm ” and “Trouble ” indicator lamp on the console/switchboard is turned

off.

- 3) The “CONTROL POSITION ” select switch (COS-L) on the machine side is set to “REMOTE ” position and the diesel engine interlock conditions are satisfied.
- 4) Stand-by generator to specify is not in LOCAL FIRE EXTINGUISH state.
These conditions 1) through 4) are met when the “READY TO START (YL15)” indicator lamp on the OP Module is turned on.
- 5) The “MODE SELECT ” push-button switch on the OP Module for each diesel generator (Not on line) is set to “AUTO ” position and “AUTO (YL1)” indicator lamp is turned on. Also, their “1st STANDBY (YL2)” or “2nd STANDBY (YL3)” or “3rd STANDBY (YL4)” indicator lamp on the OP Module is turned on to indicate this switch setting.

When generators are available as stand-by, the stand-by generator mode select function checks this switch position and each generator for “ready for automatic start” conditions and selects the generators ready for automatic start as 1st stand-by, 2nd stand-by, 3rd stand-by and so on enable in ascending order of generator Nos. (standby selection is clockwise direction on the select switch) starting from the position to which the select switch is set.

SELECTION EXAMPLE

The “SYNCHRO. SELCET” switch is set to “G2” position. Generators G1 are on line, and generators G2, G3 and G4 are ready for automatic start.

I) Order of Stand-by Generators

| | | | | | |
|-------------|-----|---|-----|---|-----|
| Stand-by : | 1st | → | 2nd | → | 3rd |
| | | | | | |
| Generator : | G2 | | G3 | | G4 |

II) Moving Up from Lower Order to Higher Order

With the stand-by generator list as in I) above, if G3 is put out of the “ready for automatic start” conditions, then G3 will be removed from the stand-by generator 1st and the order of the other stand-by generators lower in order than G3 will be moved up as follows:

| | | | |
|-------------|-----|---|-----|
| Stand-by : | 1st | → | 2nd |
| | | | |
| Generator : | G2 | | G4 |

- ##### III) With the stand-by generator list as in I) above, if G3 becomes ready for automatic start, then G3 will newly be included in the stand-by generator list with its order as determined from the select switch position.

The new stand-by generator list will be as follows:

| | | | | | |
|------------|-----|---|-----|---|-----|
| Stand-by : | 1st | → | 2nd | → | 3rd |
|------------|-----|---|-----|---|-----|

| | |
 Generator : G2 G3 G4

CAUTION Selecting an Operation mode for Controlling Generator

The "MODE SELECT" change over switch and stand-by indicator lamp are all located on the Synchro. panel. This change over switch alternately between "MANU" and "AUTO" position, causing the corresponding stand-by indicators to start bright or dark according to the respective positions.

4.2 Automatic Stand-by Connection on ACB Abnormal Trip --- (FC56) (FC58)

4.2.1 One Generator in Service (Three Stand-bys)

In the event of a ACB abnormal trip as mentioned in 4.1 ("ACB ABNORMAL TRIP"), The GAC21 Controller's generator monitor function produces the alarm signal and sends the automatic start command signal to 1st stand-by. after the started 1st stand-by has built up the voltage to 95% or more of the rated value, the 1st stand-by's ACB will be automatically closed. In the above automatic stand-by connection process, a start failure of the 1st stand-by or its ACB's non-closure will cause the 2nd stand-by to work in place of the 1st stand-by. And a start failure of the 2ndstand-by or its ACB's non-closure will cause the 3rd stand-by to work in place of the 2nd stand-by. In the event of a short circuit condition on bus, the closed generator ACB is tripped, then the 1st stand-by will be started automatically in the same way as in the above mentioned. If the short circuit condition still exists, the ACB of the 1st stand-by will be in abnormal trip state even if the ACB is closed. In this case, the 2nd stand-by will not be started.

4.2.2 Two Generators in Service (Two Stand-by)

In this case, the control process differs depending on the number of generator ACBs tripped:

(A) ACB abnormal trip of only one in parallel running: (BUS ALIVE). The stand-by is automatically started and, at the same time, the preference trip system works to trip the non-essential load circuit breakers thereby reducing the load on the generator remaining on line. after the started 1st stand-by has established voltage, the GAC21 Controller's automatic generator synchronizing function synchronizes the stand-by to the bus and puts it on line by closing its ACB at synchronism. After this, the automatic load sharing control function establishes a proportional load sharing between the two generators on line as well as maintaining the bus frequency at the rated value.

(B) ACB abnormal trip of all D/G's in parallel running: (BUS BLACK OUT)

This is a dead bus trouble (blackout), and the started stand-by's ACB will be closed as soon as its voltage has been established. In the above generator replacement process(A)(B), a start failure of the 1st stand-by or its ACB's non-closure will cause the

2nd stand-by to work in place of the 1st stand-by.

4.2.3 Three Generators in Service (One Stand-by)

In this case, the control process differs depending on the number of generator ACB's tripped:

(A) ACB abnormal trip of only one or two in parallel running: (BUS ALIVE). The stand-by is non-essential load circuit breakers thereby reducing the load on the generator remaining on line. after the started 1st stand-by has established voltage, the GAC21 Controller's automatic generator synchronizing function synchronizes the stand-by to the bus and puts it on line by closing its ACB at synchronism. After this, the automatic load sharing control function establishes a proportional load sharing between the two generators on line as well as maintaining the bus frequency at the rated value.

(B) ACB abnormal trip of all D/G's in parallel running: (BUS BLACK OUT)

This is a dead bus trouble (blackout), and the started stand-by's ACB will be closed as soon as its voltage has been established .

CAUTION Generator Feeding Trouble Continue

In the above process (A) or (B), if the 1st stand-by fails to start or its ACB fails to close, then the 2nd stand-by will be started automatically in the same way as in the above mentioned.

4.3 Automatic Generator Replacement on Bus Abnormal --- (FC57)

4.3.1 One Generator in Service (Three Stand-bys)

In the event of a bus trouble as mentioned in 4.1 (A) "BUS VOLTAGE HIGH (LOW) or BUS FREQUENCY HIGH (LOW), the GAC21 Controller 's bus monitoring function produces a associated alarm signal and sends the automatic start command signal to the 1st stand-by. When the started 1st stand-by runs and if the bus trouble still exists, then the ACB for the operating generator on line is tripped. One second later (AUTO ACB CLOSE TIME), the 1st stand-by's ACB is closed. A temporary blackout condition occurs during this transition period. The bus frequency is then automatically adjusted to and maintained at the rated value.

If the bus trouble is restored to normal at the above time point, on the other hand, the started 1st stand-by will be kept idling and in a wait state. Then if the bus trouble occurs again, the ACB for the operating generator will be tripped and, one second later, the 1st stand-by's ACB will be automatically closed.

In the above generator replacement process, a start failure of the 1st stand-by or its ACB's non-closure will cause the 2nd stand-by to work in place of the 1st stand-by. And a start failure of the 2nd stand-by or its ACB's non-closure will cause the 3rd stand-by to work in place of the 2nd stand-by.

4.3.2 Two Generators in Service (Two Stand-by)

In the event of a bus trouble as mentioned in 4.1 (A), the 1st stand-by will be automatically started to replace the generator(s) currently in service as in 4.3.1 above.

a start failure of the 1st stand-by or its ACB's non-closure will cause the 2nd stand-by to work in place of the 1st stand-by.

4.3.3 Three Generators in Service (One Stand-by)

In the event of a bus trouble as mentioned in 4.1 (A), the 1st stand-by will be automatically started to replace the generator(s) currently in service as in 4.3.1 above. Since there is no 3rd stand-by, a start failure or voltage non-establishment of the 2nd stand-by will interrupt the generator replacement process. Therefore, only the alarm is issued and the bus trouble continues without generator replacement. In the event of an ACB non-closure, since the ACB for the generator(s) in service has been tripped, the alarm is issued and a blackout condition continues. In such a case, immediate actions are required to restore the service.

4.4 Automatic Stand-by Start and Paralleling on Overload --- (FC58)

4.4.1 One Generator in Service (Three Stand-bys)

In the event of a generator overload (over current) as mentioned in 4.1 (B), the GAC21 Controller's generator monitor function produces the alarm signal and sends the automatic start command signal to 1st stand-by. At the same time, the preference trip system works to trip the non-essential load circuit breakers, thereby reducing the load on the generator remaining on line. After the started 1st stand-by has established voltage, the automatic generator synchronizing function starts to synchronize the 1st stand-by and put it on line by closing its ACB at synchronism. After this, the automatic load sharing control function establishes a proportional load sharing between the generators on line as well as maintaining the bus frequency at the rated value.

If the 1st stand-by fails to start or its ACB fails to close in the above control process, then the 2nd stand-by will be automatically to work in place of the 1st stand-by. And if the 2nd stand-by fails to start or its ACB fails to close in the above control process, then the 3rd stand-by will be automatically to work in place of the 2nd stand-by.

4.4.2 Two Generators in Service (Two Stand-by)

If overload shown in 4.1 (B) occurs, while it carries out the preferential trip of the non-essential load MCCB like the above 4.4.1, and 1st stand-by will carry out automatic starting and will carry out the automatic synchronous closing of the 1st stand-by ACB after establishment of voltage, load is distributed proportionally according to the rate of load of each generator (3 set), and bus frequency is also automatically controlled to rated value. If the 1st stand-by fails to start or its ACB fails to close in the above control process, then the 2nd stand-by will be automatically to work in place of the 1st stand-by. Since stand-by is one set when start failure of 1st stand-by or ACB of 1st stand-by is non-close, the generator under operation continues single running or parallel running state after an abnormal occurrence, only by emitting each abnormal alarm.

4.4.3 Three Generators in Service (One Stand-by)

If overload shown in 4.1 (B) occurs, while it carries out the preferential trip of the non-essential load MCCB like the above 4.4.1, and 1st stand-by will carry out automatic

starting and will carry out the automatic synchronous closing of the 1st stand-by ACB after establishment of voltage, load is distributed proportionally according to the rate of load of each generator (3 set), and bus frequency is also automatically controlled to rated value. Since stand-by is one set when start failure of 1st stand-by or ACB of 1st stand-by is non-close, the generator under operation continues single running or parallel running state after an abnormal occurrence, only by emitting each abnormal alarm.

4.5 Power Management --- (FC71-1) (FC71-2) (FC81)

4.5.1 Automatic Start and Synchro. Due To Heavy Load --- (FC71-1)

Under the condition of automation, if all consumption power is bigger than $DG \times N \times 90\%$ (DG: generator rating power, N: number of parallel running generators), the GAC21 Controller's generator monitor function produces the stand-by-start signal and sends the automatic start command signal to 1st stand-by. after the started 1st stand-by has established voltage, the automatic generator synchronizing function starts to synchronize the 1st stand-by and put it on line by closing its ACB at synchronism. After this, the automatic load sharing control function establishes a proportional load sharing between the generators on line as well as maintaining the bus frequency at the rated value.

A)One Generators in Service (Three Stand-by)

If the 1st stand-by fails to start or its ACB fails to close in the above control process, then the 2nd stand-by will be automatically to work in place of the 1st stand-by. And if the 1st stand-by fails to start or its ACB fails to close in the above control process, then the 3rd stand-by will be automatically to work in place of the 2nd stand-by.

B)Two Generators in Service (Two Stand-by)

If the 1st stand-by fails to start or its ACB fails to close in the above control process, then the 2nd stand-by will be automatically to work in place of the 1st stand-by.

c)Three Generators in Service (One Stand-by)

If the only 1st stand-by fails to start or its ACB fails to close in the above control process, then pre-trip function will be put ont.

4.5.2 Automatic Load Shift and Stop Due To Light Load --- (FC71-2)

Under the condition of automation, At least two generators parallel running, turn the change over switch "AUTO LIGHT LOAD SHIFT SELECT" to "avail" position, when the all consumption power is less than $DG \times (N-1) \times 70\%$ (DG: generator rating power; N: number of parallel generators), the GAC21 Controller's generator monitor function shift load on first generator to other generators. When the load on first generator is reduced to about 5% of its rated kW output, GAC21 produce a command "ACB OPEN" to "OPEN"ACB to remove first generator from the bus. And output a generator stop signal to stop generator after 1 minute.

4.5.3Large Motor Start Blocking Control --- (FC81)

Under the condition of automation, when a motor ask signal is sent to MSB, if the remains power (M) is less than the motor rating power(M2)($M=(DG \times N \times 90\%)-M1$; M: the

remains power; N: number of parallel running generators; M1: the all consumption power), the GAC21 Controller's generator monitor function produces the stand-by-start signal and sends the automatic start command signal to 1st stand-by. after the started 1st stand-by has ran, the automatic generator synchronizing function starts to synchronize the 1st stand- by and put it on line by closing its ACB at synchronism. After this, the automatic load sharing control function establishes a proportional load sharing between the generators on line as well as maintaining the bus frequency at the rated value. When the remains power (M) is more than the motor rating power(M2), the large motor can be permitted to start .

CHAPTER 3 MISCELLANEOUS

1. Monitoring of Insulation Level

1.1 Summary

The insulation resistance monitor (IRM) equipped respectively on 440V feeder panel and 220V feeder panel, detect the insulation level of respective 440V feeder system and 220V feeder system. If the system's insulation is deteriorated and the insulation resistance value is reduced than the predetermined set value, alarm is generated.

1.2 Insulation Resistance Monitor

- (1) This unit consists of an insulation resistance monitor and an insulation resistance meter. This enables continuous monitoring of insulation level.
- (2) Only one set of the insulation resistance monitor can be connected to the same system. If multiple number of the unit are connected to the same system, the number of earthing detection point become multiple, resulting in impossibility of current insulation resistance measurement. The insulation resistance monitors the feeder circuit insulation level when continuous earthing condition should be used under normal circumstance for continuous insulation level monitoring. If the insulation level drops below a predetermined value, the IRM will cause insulation low alarm.

(a) Detection of insulation deterioration

When main switchboard and emergency switchboard are fed as the same bus bar system, both system of main switchboard and emergency switchboard monitor the insulation level by the insulation resistance monitor of main switchboard 440V feeder bus.

(b) Judgment of insulation-deteriorated circuit

When the insulation values become lower than the initialized alarm set value, alarm is generated. After stopping the alarm, open the feeder circuit breakers one by one. At the same time, check the insulation-deteriorated circuit by an insulation resistance meter, and take necessary measures.

2. Preferential Tripping System --- (FC51)

(1) Purpose

When the generator on line is overloaded, relatively non-essential load is tripped from the system by the preferential tripping system, to reduce the load of generator. Thus the operation of generator continues and the feeding to essential load circuits continues. The preferential tripping system of this ship has two kinds of "Tripping", namely, one by overload of the generator, and the other by abnormal ACB trip of the generator during parallel operation of generators.

(2) Operation

(a) Separation of non-essential load due to overload.

If the load current of generator on line becomes higher than the preferential trip set value, PREFERENTIAL TRIP function among the over current tripping device functions of ACB operate to trip the MCCB for non-essential load. For the MCCB designated for non-essential load, a thin yellow plate is inserted under its nameplate specifying its application purpose. This indicates the preferential breaking designation.

(b) Separation of non-essential load by abnormal tripping of the generator ACB.

The preferential tripping takes place alike (a) above also when the ACB of one unit out of the generator ACBs in parallel operation is tripped by a trouble.

3. Overload Protection of Generators

After the preferential tripping as described in (2) (a) of section 2. above this chapter, when the generator is further overloaded, Long Time Delay Trip (LTD) function among the functions of over current tripping device of ACB operates to trip the ACB of generator to prevent damage in the generator.

4. ACB TROUBLE RESET Push-button Switch

CAUTION Generator ACB Abnormal Trip Resetting

Before, press this push-button switch, confirm protection device on generator ACB.

(a) The indicator lamp "ACB TROUBLE RESET "with the push-button

switch on the according generator panel turned on. This is turned on by such failures as ACB SYSTEM ABNORMAL, ACB NON CLOSE, AUTO SYNCHRO FAIL, ACB ABNORMAL TRIP or ACB SHORT CIRCUIT TRIP. By pressing the push-button switch in the indicator lamp is turned off and the ACB closing circuit is reset to normal.

(b) By a short circuit trouble on main bus bar, the related ACB is tripped, and the indicator lamp "ACB TROUBLE RESET "with the push-button switch on the according generator panel is turned on. At the same time, the re-closing prevention circuit is operated to prevent the closing of the ACB. By pressing the push-button switch on, the re-closing prevention is released .At the same time, the indicator lamp with the push-button switch is turned off making the closing of the ACB. When unable to reset by push-button switch for case (a) and (b) above, confirm the generator ACB protection device.

5. Trouble Alarm System for Main switchboard

(1) When the abnormalities occur, output the following failure cause signal to ECC from a main switchboard.

DC24V LOW INSULATION

BUSBAR VOLT. HIGH

BUSBAR VOLT. LOW

BUSBAR FREQ. HIGH

BUSBAR FREQ. LOW

MSB 440V LOW INSUL.

MSB 220V LOW INSUL.

ESB 440V LOW INSUL.
 ESB 220V LOW INSUL.
 MSB CONTROL SYSTEM ABNORMAL
 ESB SYSTEM ABNORMAL
 PRE-TRIP1
 PRE-TRIP2
 FORWARD AC220V LOW INSULATION
 MSB EM'CY STOP&PRE-TRIP SOURCE FAILURE
 MSB ACB ABNORMAL TRIP

(2) The corresponding failure cause indicator lamp on synchro. panel lights up, and abnormalities are reported.

The machine side handle switch of generator engine control circuit will reset the disable start control circuit and alarm circuit. The trouble alarm lamp on the MSB synchro. Panel also turn off and then the engine control circuit return to the normal state.

6. Switching of Control Power Source for Main Bus bar and Disconnecting of Main Bus bar Duplication

The following select switch and disconnecting device is installed on the No.2 generator panel rear of inside.

CAUTION Handling of Control Power Source Select Switch

After opening the main bus bar duplication bolt link, set the "MAIN BUS CONTROL SOURCE "select switch (COS-B) to a SOUND BUSBAR side. Setting this select switch to any position will usually cause no trouble. But do not change the select switch position during normal operation. Doing so could cause a malfunction to occur in control and monitoring circuits.

1. Operation of Bolt Link for Main Bus bar Duplication

- 1.1 Do not open/close the disconnecting device under ON LOAD condition.
- 1.2 Do not touch the live parts. Doing so will cause electric shock.
- 1.3 Make sure each of the three phases is correctly connected after installing the bolt link. Make sure all of the three phases are disconnected after removing the bolt link.
- 1.4 After opening the bus bar duplication bolt link, set the "MAIN BUS CONTROL SOURCE "select switch (COS-B) to a SOUND BUSBAR side.

2. Limitations in Generator Operation

When a fault occurs and the bus bar duplication bolt link is opened.

Do not operate generators connected to the faulty bus bar until the fault is removed.

Turn off the GENERATOR AUTOMATIC START and ACB AUTOMATIC CLOSE functions and set

all generator related control functions to MANUAL.

7. DIFFERENTIAL PROTECTION

when differential protection relay acts for some fault caused inside generator, the following three function will be put out simultaneously to protect generator.

1. open UVT power circuit to open ACB.
2. close "DE-EXCITE" circuit to stop voltage output. The "DE-EXCITE" circuit can be opened by pressing push button "DG DIFFERENTIAL ALARM RESET".
3. GAC21 output a "ENG STOP" command to stop engine.

End