WOODWARD

Application Note 51207
(Revision A)

Original Instructions

Configuration of EGCP-3 Controls for Sequencing

General Precautions

Read this entire manual and all other publications pertaining to the work to be performed before installing, operating, or servicing this equipment.

Practice all plant and safety instructions and precautions.

Failure to follow instructions can cause personal injury and/or property damage.

Revisions

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Proper Use

Any unauthorized modifications to or use of this equipment outside its specified mechanical, electrical, or other operating limits may cause personal injury and/or property damage, including damage to the equipment. Any such unauthorized modifications: (i) constitute "misuse" and/or "negligence" within the meaning of the product warranty thereby excluding warranty coverage for any resulting damage, and (ii) invalidate product certifications or listings.

Translated Publications

If the cover of this publication states "Translation of the Original Instructions" please note:

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Warnings and Notices

Important Definitions

This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.

- **DANGER**—Indicates a hazardous situation which, if not avoided, will result in death or serious injury.
- **WARNING**—Indicates a hazardous situation which, if not avoided, could result in death or serious injury.
- **CAUTION**—Indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.
- **NOTICE**—Indicates a hazard that could result in property damage only (including damage to the control).
- **IMPORTANT**—Designates an operating tip or maintenance suggestion.

⚠WARNING

Overspeed / Overtemperature / Overpressure

The engine, turbine, or other type of prime mover should be equipped with an overspeed shutdown device to protect against runaway or damage to the prime mover with possible personal injury, loss of life, or property damage.

The overspeed shutdown device must be totally independent of the prime mover control system. An overtemperature or overpressure shutdown device may also be needed for safety, as appropriate.

⚠WARNING

Personal Protective Equipment

The products described in this publication may present risks that could lead to personal injury, loss of life, or property damage. Always wear the appropriate personal protective equipment (PPE) for the job at hand. Equipment that should be considered includes but is not limited to:

- **Eye Protection**
- **Hearing Protection**
- **Hard Hat**
- **Gloves**
- **Safety Boots**
- **Respirator**

Always read the proper Material Safety Data Sheet (MSDS) for any working fluid(s) and comply with recommended safety equipment.

⚠WARNING

Start-up

Be prepared to make an emergency shutdown when starting the engine, turbine, or other type of prime mover, to protect against runaway or overspeed with possible personal injury, loss of life, or property damage.

⚠WARNING

Automotive Applications

On- and off-highway Mobile Applications: Unless Woodward's control functions as the supervisory control, customer should install a system totally independent of the prime mover control system that monitors for supervisory control of engine (and takes appropriate action if supervisory control is lost) to protect against loss of engine control with possible personal injury, loss of life, or property damage.

NOTICE

Battery Charging Device

To prevent damage to a control system that uses an alternator or battery-charging device, make sure the charging device is turned off before disconnecting the battery from the system.

Electrostatic Discharge Awareness

NOTICE

Electrostatic Precautions

Electronic controls contain static-sensitive parts. Observe the following precautions to prevent damage to these parts:

- **Discharge body static before handling the control (with power to the control turned off, contact a grounded surface and maintain contact while handling the control).**
- **Avoid all plastic, vinyl, and Styrofoam (except antistatic versions) around printed circuit boards.**
- **Do not touch the components or conductors on a printed circuit board with your hands or with conductive devices.**

To prevent damage to electronic components caused by improper handling, read and observe the precautions in Woodward manual *82715*, *Guide for Handling and Protection of Electronic Controls, Printed Circuit Boards, and Modules*.

Follow these precautions when working with or near the control.

1. Avoid the build-up of static electricity on your body by not wearing clothing made of synthetic materials. Wear cotton or cotton-blend materials as much as possible because these do not store static electric charges as much as synthetics.
2. Do not remove the printed circuit board (PCB) from the control cabinet unless absolutely necessary. If you must remove the PCB from the control cabinet, follow these precautions:
   - Do not touch any part of the PCB except the edges.
   - Do not touch the electrical conductors, the connectors, or the components with conductive devices or with your hands.
   - When replacing a PCB, keep the new PCB in the plastic antistatic protective bag it comes in until you are ready to install it. Immediately after removing the old PCB from the control cabinet, place it in the antistatic protective bag.

Configuration of EGCP-3 Controls for Sequencing

Introduction

Sequencing operation of EGCP-3 LS units is designed to function as a supervisory control that allows operators to configure the control to their system specifications. The controls are set up to start and stop gensets on a percentage of rated load basis and can be configured for six different sequencing types:

- Disabled
- Staggered Run Time
- Equal Run Time
- Smallest Unit First
- Largest Unit First
- Node Number

The mechanism of how the sequencing works is similar for all control types, but setting up the sequencing can create problems if configured incorrectly. This application note describes setup for every type of sequencing mechanism as well as problems that could occur with improper configuration.

Sequencing Types

Disabled

When the Run-Time Manager is set for Disabled operation, no individual sequencing is performed, but all starts initiated by an EGCP-3 MC will still occur. This feature allows an operator to keep single units or all units online all of the time. An example of this would be a plant with a large constant load and a smaller variable load. Knowing the plant's load profile, the operator might want to keep a large generator on all of the time supplying the large constant load. Other generators could be configured with another sequencing type and supply the varying load by sequencing units on and off the bus during the variations. Figure 1 illustrates the use of this type of sequencing.

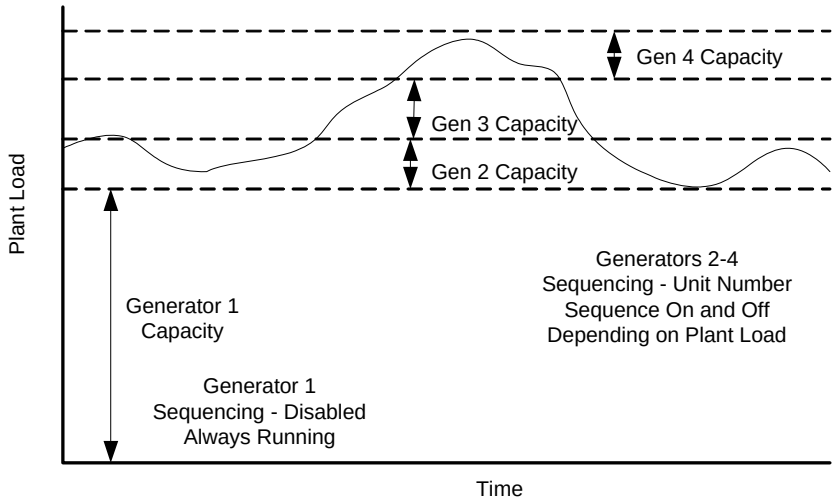

Figure 1. Disabled Sequencing

IMPORTANT

Disabled is the only sequencing algorithm that can be configured with another algorithm. For example, all units must be on Staggered Run Time or Disabled. The controls cannot have Staggered and Unit number. If the controls are configured incorrectly, a LON ERROR 261 will be present in:

- **W LON MESSAGING—62 ERROR NUMBER for the LS**
- **U LON MESSAGING—58 LON OUT – ERR NUM for the MC**

Staggered Run Time

Staggered Run Time sequencing applies the Service Interval in its sequencing mechanism. The Service Interval is configured in the Sequencing menu and is set up so that alarms can be configured when this time expires. When a genset is running, its service hours decrement. This sequencing algorithm attempts to stagger the service hours so that single units can be taken out of service for repairs and maintenance at different times. When a start is requested on the network, the algorithm looks for the LS unit with the least amount of service hours remaining and starts that unit. On a stop request, the unit with the largest amount of service hours remaining is stopped. If there is an equal amount of service hours on two LS gensets, the LS unit with the lowest unit number is started or stopped. Figure 2 illustrates how this algorithm functions.

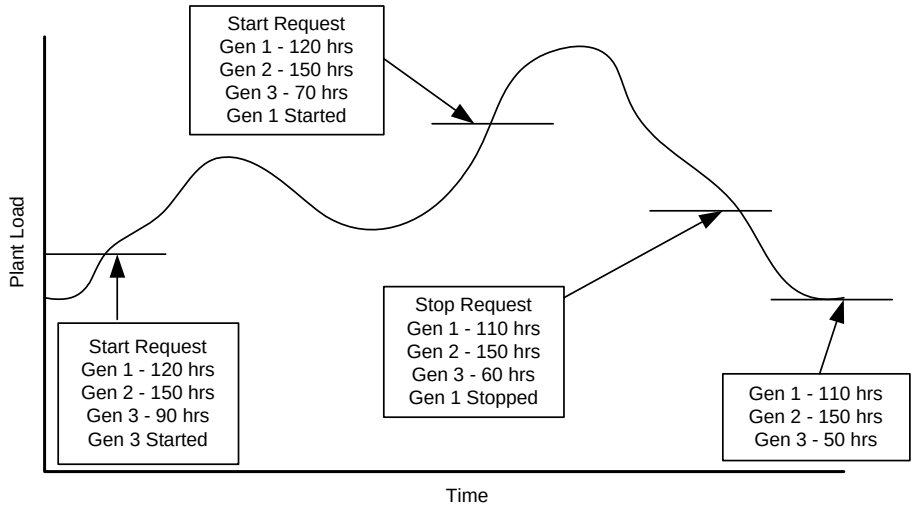

Figure 2. Staggered Run Time Sequencing

Equal Run Time

Equal Run Time sequencing applies the Service Interval in its sequencing mechanism. The Service Interval is configured in the Sequencing menu and is set up so that alarms can be configured when this time expires. When a genset is running, the service hours decrement. This sequencing algorithm attempts to equal all of the gensets the service hours so that all units can be taken out of service for repairs and maintenance at the same time. When a start is requested on the network, the algorithm looks for the LS unit with the largest amount of service hours remaining and starts that unit. On a stop request, the unit with the least amount of service hours remaining is stopped. If there is an equal amount of service hours on two LS gensets, the LS unit with the lowest unit number is started or stopped. Figure 3 illustrates how this algorithm functions.

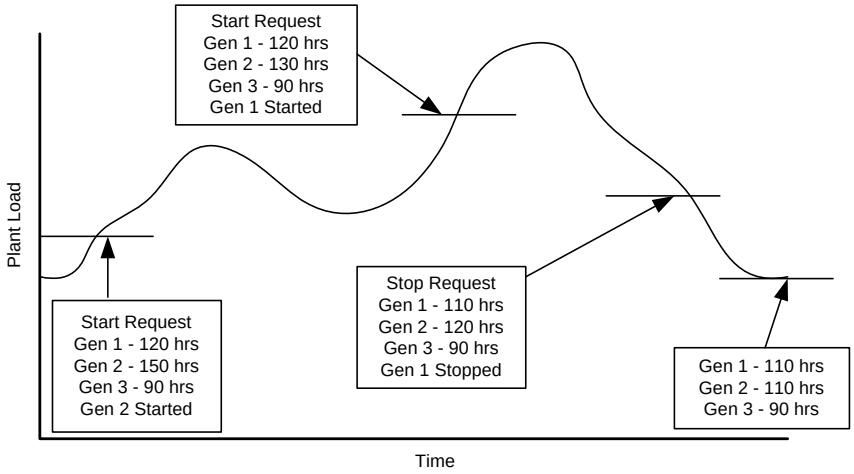

Figure 3. Equal Run Time Sequencing

Largest Unit First

The Largest Unit First sequencing algorithm starts the largest real load capacity unit upon a start request and stops the smallest real load capacity unit upon a stop request. The stopping order will always be exactly the opposite of the starting order. This sequencing algorithm is best used for plants with large load changes and large differences in the size of the gensets available. Figure 4 illustrates how the algorithm functions.

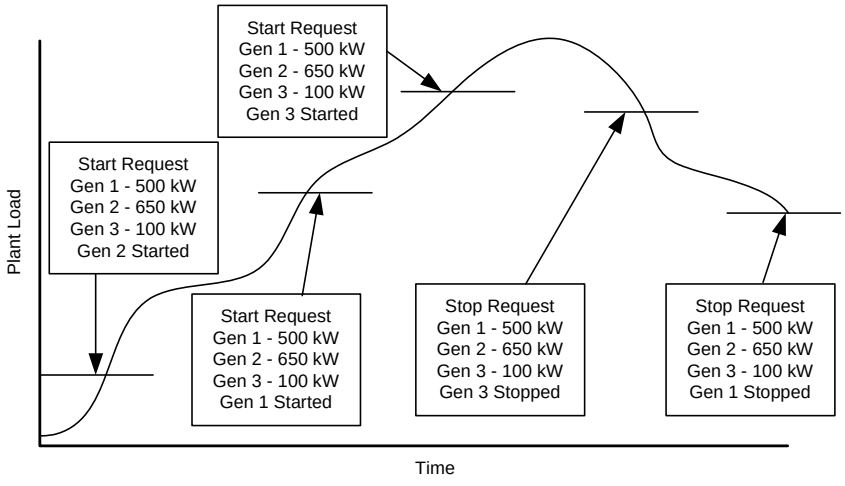

Figure 4. Largest Unit First Sequencing

Smallest Unit First

The Smallest Unit First sequencing algorithm starts the smallest real load capacity unit upon a start request and stops the largest real load capacity unit upon a stop request. The stopping order will always be exactly the opposite of the starting order. This sequencing algorithm is best used for plants where large units only need to be operated during small periods of large plant load, and during all other periods, the load is fairly constant. Figure 5 illustrates how the algorithm functions.

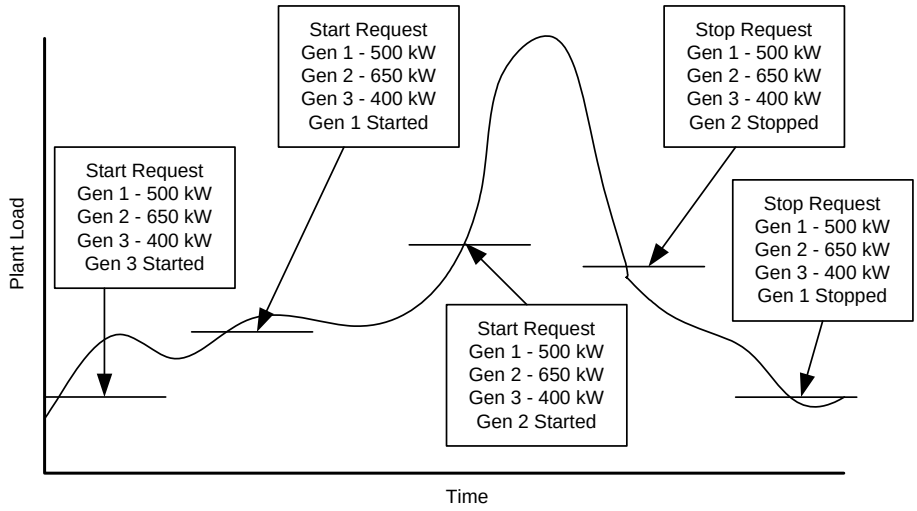

Figure 5. Smallest Unit First Sequencing

Unit Number

The Unit Number sequencing algorithm starts the LS genset with the lowest node number upon a start request and stops the unit with the lowest node number upon a stop request. The stopping order will always be exactly the same as the starting order. Figure 6 illustrates how the algorithm functions.

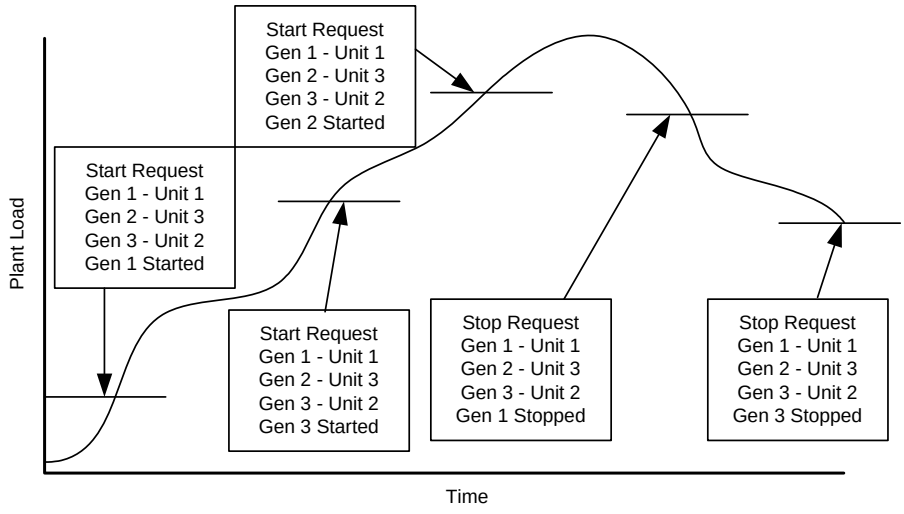

Figure 6. Unit Number Sequencing

Sequencing Mechanism

The operator has several configurations to work with in the sequencing menu.

- Run-Time Manager
  Type of sequencing performed by LS units
- Max Load Delay
  Time above the Max Gen Load Level before the next unit is started
- Rated Load Delay
  Time above rated load before the next unit is started
- Reduced Load Delay
  Time below the Min Gen Load Level before the next unit is stopped
- Max Gen Load Level
  Percent of system load at which one unit should be sequenced on
- Min Gen Load Level
  Percent of system load at which one unit should be sequenced off
- Stop Gen Time
  Time between a LON stop attempt before the next stop attempt it tried
- Start Gen Time
  Time between a LON start attempt before the next start attempt it tried
- Service Interval
  Hours between service periods
- Reset Service Hours
  Resets the Service hours to the service interval
- Auto Start Sequence Alarm
  Alarm if the LON has requested three starts separated by the Start Gen Time and a Start Done has not been received
- Auto Stop Sequence Alarm
  Alarm if the LON has requested three stops separated by the Stop Gen Time and a Stop Done has not been received
- Service Hours Alarm
  Alarm occurs if service hours reaches zero

The sequencing algorithm is based on System Load. System load is the percentage of rated load on the gensets. For example, if there are two units online, one rated at 500 kW and the other at 200 kW, and the system load is 50%, the units will be generating 250 kW and 100 kW respectively. The sequencing algorithm uses two setpoints and three delays for all action taken. The following diagrams the action.

- System Load > **Max Gen Load Level** for **Max Load Delay**
  Start Request is sent over LON
- System Load = **100% for Rated Load Delay**
  Start Request is sent over LON
- System Load < **Min Gen Load Level** for **Min Load Delay**
  Stop Request is sent over LON

Start and stop requests will depend on which sequencing type is configured as discussed in the previous section. Take care when configuring the max and min gen load levels in order to avoid overloading a genset, especially when units are being sequenced offline. The following section describes how to configure these levels to eliminate the possibility of overloading a unit.

Sequencing Configuration

In order to avoid overloading, and also to increase efficiency of operation, the sequencing configurables Max Gen Load Level and Min Gen Load Level need to be analyzed for different sized units and also for different sequencing types. The most important transition that needs to be analyzed is the sequencing of gensets offline in isolated operation, especially if the transition is from two units online to one unit online. The following setup will be analyzed for different types of sequencing operation:

- Generator 1—200 kW Rated Capacity
- Generator 2—400 kW Rated Capacity
- Generator 3—600 kW Rated Capacity

For all sequencing operations, the first decision that needs to be made is the value of the Max Gen Load Level. This value can be arbitrarily selected and depends on operator preference. Usually the efficiency of operation is a top priority and having the gensets close to their rated capacity when online is a key factor in improving the efficiency of the system. For the following examples, a value of 90% was chosen for the Max Gen Load Level.

Additionally, every sequencing case needs to take into consideration three configuration errors:

- Overloading of a single unit online
- Start/Stop cycling
- Double starting

Overloading can be eliminated if the Min Gen Load Level is selected such that the system load on one generator will never exceed 100%.

Start/Stop cycling occurs when the Min Gen Load Level and Max Gen Load Level are too close together when a unit is taken offline or placed online. This occurs when the addition of another unit online creates a system load that is below the Min Gen Load Level, but its removal (taken offline) creates a system load that is above the Max Gen Load Level. This setup creates a perpetual start/stop action around that load level.

Double starting can occur if the Load Time (Real Load Control Menu) is very large and the Max Load Delay is very short. The problem occurs after a genset has been sequenced online and has closed its breaker to the bus. When the breaker closes, the Max Load Delay begins to decrement again because the load is above the Max Gen Load Level. If the delay expires because the genset took too long to ramp load, the system load could still be above the Max Gen Load Level, and the system could request another start. To eliminate this problem, the Load Time should be less than the Max Load Delay.

The next sub-sections details how to avoid the first two problems for different sequencing types.

Largest to Smallest

The largest to smallest stop sequence will be Gen1 – Gen 2 – Gen 3. This can occur for any sequencing type except Smallest Unit First.

Number of Units Online:	3 (System Capacity = 1200 kW)
Initial Plant Load:	1000 kW
Initial System Load:	83.3%

Plant load decreases to 900 kW (System Load = 75%). By setting the Min Gen Load Level below 75%, start/stop cycling will be eliminated when Gen 1 is taken offline but may not eliminate the overloading of Gen 3 when Gen 2 is taken offline.

Number of Units Online:	2 (System Capacity = 1000 kW)
Plant Load:	890 kW
System Load:	74.2%

Plant load decreases to 600 kW (System Load = 60%). By setting the Min Gen Load Level below 60%, overloading of Gen 3 will be eliminated but start/stop cycling will occur between Gen 2 and Gen 3 as seen below:

Number of Units Online:	2 (System Capacity = 1000 kW)
Min Gen Load Level:	60%
Plant Load:	590 kW
System Load:	59% (Stop Request to Gen 2)

Number of Units Online:	1 (System Capacity = 600 kW)
Plant Load:	590 kW
System Load:	98.3% (Start Request to Gen 2)

This start/stop cycling will continue to occur at this load level. To eliminate this problem, the Min Gen Load Level needs to be less than 90% of rated load on Gen 3 (540 kW).

Number of Units Online:	2 (System Capacity = 1000 kW)
Plant Load:	540 kW
System Load:	54%

Setting the Min Gen Load Level below 54% will eliminate overloading and start/stop cycling. Setting the level at 52% will create sequencing at the following load levels:

Gen 1—624 kW
Gen 2—520 kW

The units will be sequenced on at load levels:

Gen 1—900 kW
Gen 2—540 kW

Smallest to Largest

The smallest to largest stop sequence will be Gen 3 – Gen 2 – Gen 1. This can occur for any sequencing type except Smallest Unit First.

Number of Units Online:	3 (System Capacity = 1200 kW)
Initial Plant Load:	1000 kW
Initial System Load:	83.3%

Plant load decreases to 540 kW (System Load = 45%). By setting the Min Gen Load Level below 45%, start/stop cycling will be eliminated when Gen 1 is taken offline but may not eliminate the overloading of Gen 1 when Gen 2 is taken offline.

Number of Units Online:	2 (System Capacity = 600 kW)
Plant Load:	530 kW
System Load:	88.3%

Plant load decreases to 200 kW (System Load = 33.3%). By setting the Min Gen Load Level below 33.3%, overloading of Gen 1 will be eliminated but start/stop cycling will occur between Gen 2 and Gen 1 as seen below:

Number of Units Online:	2 (System Capacity = 600 kW)
Min Gen Load Level:	33.3%
Plant Load:	190 kW
System Load:	31.7% (Stop Request to Gen 2)

Number of Units Online:	1 (System Capacity = 200 kW)
Plant Load:	190 kW
System Load:	95% (Start Request to Gen 2)

This start/stop cycling will continue to occur at this load level. To eliminate this problem, the Min Gen Load Level needs to be less than 90% of rated load on Gen 1 (180 kW).

Number of Units Online:	2 (System Capacity = 600 kW)
Plant Load:	180 kW
System Load:	30%

Setting the Min Gen Load Level below 30% will eliminate overloading and start/stop cycling. Setting the level at 28% will create sequencing at the following load levels:

Gen 3—336 kW
Gen 2—168 kW

The units will be sequenced on at load levels:

Gen 3—540 kW
Gen 2—180 kW

Summary

By applying sequencing functionality to a system, efficiency can be improved and maintenance can be reduced. Avoiding sequencing configuration errors is critical to obtaining optimum performance from the EGCP-3. With an understanding of the process of sequencing, operators should be able to custom fit the EGCP-3 network to their system. By running through the above calculations with your system, problems can be eliminated and performance improved.

We appreciate your comments about the content of our publications.

Send comments to: icinfo@woodward.com

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