marathon™
Thomson Power Systems

SUGGESTED SPECIFICATION

DISTRIBUTED GENERATION CONTROL

GENERATOR SWITCHGEAR

GCS 2200

Specification No. ES017 – GCS 2000 DG

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1. SCOPE

Specification writer's notes:

1. This suggested specification is intended for typical Distributed Generation control systems. The typical control scheme would consists of the following main characteristics:
    - Single or multiple generator applications
    - Peak Shaving or Co-generation operation with electrical and or thermal load following
    - Automatic Standby Operation on loss of utility supply
    - Bumpless power transfer (make before break, soft power transfer logic to provide uninterruptible power transfer).

For generator paralleling switchgear specifications or different control schemes, contact Thomson Power Systems for alternate sample specifications as available.

2. Included in this suggested specification are sections identified as **"Alternates"**. These sections provide the specifying engineer many design options which allow for system customizing and possible cost saving opportunities. In general, **"Alternates"** typically provide more cost effective design solutions however the specifying engineer should use discretion based on specific application requirements.

> ***Note:***
> ***The following information is provided by Thomson Power Systems as a guide only for use by specifying engineers in designing generator switchgear systems. All system designs and installations must be done in accordance with all applicable electrical regulation codes and practices as required. Please contact Thomson Power Systems for any additional information.***

2. GENERAL REQUIREMENTS

2.1. GENERAL

2.1.1. The control system shall be manufactured in accordance with this specification and applicable CSA, IEC, NEMA, UL, and ANSI standards.

2.1.2. Supplier shall be responsible for ensuring the compatibility of all components of the unit.

2.1.3. The unit shall be free of defects in material and workmanship.

2.2. RELATED INDUSTRY STANDARDS

2.2.1. **UL-891** Low Voltage Switchgear

2.2.2. **UL-508** Industrial Control Equipment Standard

2.2.3. **UL1558** Metal Clad Low Voltage Switchgear

2.2.4. **ANSI C37** Medium Voltage Switchgear

2.2.5. **CSA-C22.2 No.31** Switchgear

2.2.6. **NEMA-No ICS 10** Industrial Control and Systems AC Switchgear Equipment

Specification writer's note: Remove all non-applicable industry standards as required for the intended location of the equipment.

2.3. ENVIRONMENTAL CONDITIONS

2.3.1. The unit shall be installed indoors with ambient temperatures between 0 degrees and +50 degrees Celsius, relative humidity from 0-95% non condensing.

3. FUNCTIONAL REQUIREMENTS

3.1. GENERAL DESCRIPTION

GENERATOR PARALLELING SWITCHGEAR

The generator switchgear shall have provisions for three basic modes of operation:

1. **Parallel Generation Power Transfer**: The system shall have provisions to automatically synchronize the generator supply to the utility supply for peak shaving, co-generation or load testing operation.

2. **Uninterrupted Power Transfer**: The system shall automatically transfer the load to the generator supply in the event of a utility supply failure and return the load to the utility supply upon restoration. All power transfers shall utilize "make-before-break" switching logic when both sources of power are available. All power transfers shall occur at a zero power level utilizing a soft load ramping feature.
3. **Interrupted Power Transfer**: The system shall automatically transfer the load to the generator supply in the event of a utility

supply failure and return the load to the utility supply upon restoration. All power transfers shall utilize “break -before-make” switching logic. The generator switchgear power switching devices shall electrically interlocked to prevent the utility and generator supplies from being interconnected.

3.2. **SEQUENCE OF OPERATION (Parallel Generation Mode)**

Note: For specific device settings refer to section 3.5 “CONTROL FEATURES."

3.2.1. There are three methods by which peak shave operation may be initiated: manually initiated or automatically initiated by either load demand or timed cycle.

- **Manually Initiated Peak Shave** - The operator may manually initiate peak shave by selecting peak shave initiate at either the operator interface or remotely via a comm link to the Distributed Generation paralleling switchgear .
- **Automatic Load Demand)** - When the load demand rises above the peak shave start setpoint, the peak shave start timer will begin timing. Once start time delay expires, the generator will start and parallel to the utility. When the load demand falls below this setpoint for the duration of the peak shave stop timer the generator will perform a controlled shutdown (unload, trip, cooldown). **Note**: The stop delay timer will be automatically bypassed if the minimum import or maximum export level is reached and the load on the generator falls below the zero power transfer setpoint. This is provided to prevent unnecessarily tripping the generator on reverse power.
- **Automatic Timed Cycle** - A 28 day clock is programmed into the PLC to allow setting of an automatic exercise cycle, each day may be individually enabled. If timed cycle peak shave is enabled, when PLC clock reaches the start time the generator will start and parallel to the utility. When the stop time is reached the generator will perform a controlled shutdown (unload, trip, cooldown).

3.2.2. Once the generator set receives a start signal from one of the peak shave starting logic methods, the engine shall immediately start and accelerate to nominal voltage and frequency levels. Once correct voltage and frequency levels have been obtained, the unit shall be automatically synchronized to the utility supply. The control system shall provide automatic frequency and voltage matching synchronizers.

3.2.3. Once the generator set has achieved synchronism, the generator transfer breaker shall automatically close to connect the generator to the utility supply.

3.2.4. Once the generator transfer breaker has closed, the generators Kw and Kvar output shall be automatically controlled to prevent possible overloading or reverse power conditions.

3.2.5. The Kvar load on the generator shall immediately attain a preset Kvar load setpoint or Power factor setpoint(selectable) for the generator. The generators Power Factor shall typically be set to maintain a 0.8PF loading on the generator to attain maximum capability.

3.2.6. The Kilowatt load on the generator shall be slowly ramped up at a controlled rate. The generator Kilowatt setpoint shall be determined by the selected Load Control Mode. Two Load Control modes shall be provided as follows:

- **Base Load** - the generator will load up to and maintain the base load Kilowatt setpoint, provided the maximum export level is not exceeded.
  Note: Two related setpoints are also provided. Peak shave generator output limit, this may be set to limit the generators output while operating in the peak shave mode. Maximum export, this will limit the ability of the generator to supply power to the utility grid. The maximum export setting will override the base load setpoint.
- **Minimize Import** - The generator will load up until the utility supply is unloaded to the minimum utility import load level setpoint, provided the maximum export and generator load limit settings are not exceeded.
  Note: Two related setpoints shall be provided. Peak shave generator output limit, this may be set to limit the generators output while operating in the peak shave mode. Maximum export, this will limit the ability of the generator to supply power to the utility grid. The maximum export setting will override the minimum import setpoint.

3.2.7. Should the utility supply fail during the parallel generation mode, sensitive protective relays shall immediately operate to issue a trip signal to the utility transfer breaker to separate the generator and utility supplies. The generator shall remain operating on load.

3.2.8. Should the generator supply fail during the parallel generation mode, sensitive protective relays shall immediately operate to issue a trip signal to the generator transfer breaker to separate the generator and utility supplies. The utility transfer breaker shall remain closed to keep the load energized.

3.2.9. When the parallel generation mode is terminated the generator shall automatically ramp down its Kilowatt load via controlled ramp rate and when a zero power setpoint is reached, the generator transfer breaker shall trip open. The engine shall continue to operate for its cooldown period before stopping.

3.3. SEQUENCE OF OPERATION (Uninterrupted Power Transfer Mode)

Note: For specific device settings refer to section 3.5 “CONTROL FEATURES."

3.3.1. When the voltage on any phase of the utility supply is below preset levels of rated voltage for a preset time delay, a contact shall close to initiate starting of the generator set.

3.3.2. The utility transfer breaker shall trip and then the generator transfer breaker shall close to transfer the load to the generator supply when the generator voltage and frequency have reached acceptable preset levels and the warm-up time delay has expired.

3.3.3. When the utility supply is restored to above preset levels of rated voltage on all phases, the utility return delay timer is initiated.

3.3.4. Once the utility return delay timer has expired, the generator shall automatically synchronize to the utility supply. Once the generator is in synchronism with the utility supply, the utility transfer breaker shall close to parallel the two sources.

3.3.5. Once the utility transfer breaker has closed, the Kilowatt and Kvar load shall be automatically controlled to prevent possible overloading or reverse power conditions. The Kvar load on the generator shall be maintained at a 0.8 power factor (lagging) level (adjustable). The Kilowatt load on the generator shall be slowly ramped down and load ramped up onto the utility supply.

3.3.6. When a zero power transfer signal is detected across the generator transfer breaker, the generator transfer breaker shall trip open to disconnect the two supplies.

3.3.7. Should the utility supply fail during the uninterrupted power transfer sequence (i.e. when both sources are paralleled), sensitive protective relays shall immediately operate to issue a trip signal to the utility transfer breaker to separate the generator and utility supplies. The generator shall remain operating on load.

3.3.8. Should the generator supply fail during the uninterrupted power transfer sequence (i.e. when both sources are paralleled) , sensitive protective relays shall immediately operate to issue a trip signal to the generator transfer breaker to separate the generator and utility supplies. The utility transfer breaker shall remain closed to keep the load energized.

3.3.9. The load shall immediately retransfer to the utility supply (if within acceptable limits) should the generator supply fail prior to expiry of the utility transfer delay.

3.3.10. The generator set shall continue to operate following a load transfer for a cooldown delay period, then a contact shall open to stop the generator set.

3.4. SEQUENCE OF OPERATION (Interrupted Power Transfer Mode)

Note: For specific device settings refer to section 3.5 “CONTROL FEATURES."

3.4.1. When the voltage on any phase of the utility supply is below preset levels of rated voltage for a preset time delay, a contact shall close to initiate starting of the generator set.

3.4.2. The utility transfer breaker shall trip and then the generator transfer breaker shall close to transfer the load to the generator supply when the generator voltage and frequency have reached acceptable preset levels and the warm-up time delay has expired.

3.4.3. When the utility supply is restored to above preset levels of rated voltage on all phases, the load shall retransfer to the utility supply following expiry of the utility return timer. When the transfer occurs, the generator transfer breaker shall trip open, then following the neutral delay period, the utility transfer breaker shall close to compete the retransfer sequence.

3.4.4. The load shall immediately retransfer to the utility supply (if within acceptable limits) should the generator supply fail prior to expiry of the utility transfer delay.

3.4.5. The generator set shall continue to operate following a load transfer for a cooldown delay period, then a contact shall open to stop the generator set.

3.4.6. An “on load” test mode may be initiated which shall cause a simulated utility failure condition and transfer the load to the generator set as per the normal sequence.

3.4.7. The load shall immediately retransfer to the utility supply (if within acceptable limits) should the generator supply fail during a test mode.

3.5. DISTRIBUTED GENERATION CONTROL FEATURES

The following control features shall be provided for the distributed generation

control system:
Note: the following description provided is for a typical single generator application using 2 circuit breakers to interconnect the generator, and utility supply. For other configurations, please contact Thomson Power Systems

3.5.1. Three basic modes of operation shall be provided by the Distributed Generation control system: parallel generation uninterrupted transfer and interrupted transfer. Each mode shall be operator selectable.

3.5.2. All power transfers in the uninterrupted or parallel generation modes shall utilize a zero power transfer set point to provide a "soft" power transfer.

3.5.3. Utility grade protective relays shall be provided for the utility supply to satisfy all applicable utility company interconnect regulations. These protective relays shall ensure the generator separates from the utility supply during a failure of either source. As a minimum, the following protective relays shall be provided:

- 3 Phase under/overvoltage/negative sequence relay(47/27/59)
- under/over frequency relay (81-O/U)
- 3 phase utility reverse power relay (32) (optional-not required for export power configuration
- Synchronizing check relay (25)

3.5.4. Generator protective relays shall be provided for safe parallel operation.. As a minimum, the following protective relays shall be provided:

- Synchronizing check relay (25)
- Generator reverse power relay (32)

3.5.5. Automatic Kvar and Power factor control shall be provided for the generator. The Kvar controller shall provide either Kvar or Power Factor control modes and shall be user selectable. Kvar or Power Factor settings shall be user adjustable. The controller shall be compatible with the generator's automatic voltage regulator.

3.5.6. Automatic Kw controls shall be provided for the generator. The Kw controller shall have adjustable setpoints for maximum generator output, utility import power level, and ramping time delay. The Kw controller shall be compatible with the engines electronic governor.

3.5.7. A speed matching Automatic Synchronizer compatible with the engine's electronic governor shall be provided. It shall monitor the voltage, frequency and phase angle of the incoming generator to the load bus, and provide automatic breaker closure signal when in synchronism. The automatic synchronizer shall have adjustable gain

and stability for optimal synchronizing speed. The automatic synchronizer shall be provided with voltage matching control outputs for interface to the generators voltage regulator.

3.5.8. An Operator Interface shall be provided for the Distributed Generation control system. The Operator Interface shall provide system status annunciation, control mode selection and load parameter setpoint adjustability. The Operator interface screen shall be minimum 5" x 6", LCD 16 color with touch screen and numeric keypad.

3.5.9. The following status/annunciation screens shall be provided on the Operator Interface panel:

3.5.9.1. Single Line Diagram **-** A dynamic single line diagram shall be displayed to provide the following information: Breaker positions, Operating Modes, Status of the utility and generator, Analog parameters and timer counts

3.5.9.2. Alarm/Status Screen **-** An alarm pop-up screen shall be provided to indicate current alarms and an alarm history. Following is a list of alarms and states:

- System Operation Not in Auto
- Maximum Export Limit Reached
- Utility Failed during Parallel Operation
- Fail to Synchronize Alarm
- Dead Bus Relay Failed Alarm
- 52G Breaker Failed to Open
- Utility Undervoltage
- Utility Overvoltage
- Utility Under Frequency
- Utility Over Frequency
- Utility Directional Overcurrent
- Utility Protection Relay Diagnostic Warning
- 52U Close Coil Failed
- 52U Trip Coil Failed
- Engine Controller Not in Auto
- Engine/Generator Common Alarm
- Engine/Generator Common Shutdown
- Load Demand Peak Shave Start
- Timed Cycle Peak Shave Start
- Utility Power Failed Start
- Peak Shave Locally Initiated
- Peak Shave Remotely Initiated
- Start Relinquished
- 52G Breaker: Closed / Opened
- 52U Breaker: Closed / Opened

- System Operation: Auto / Manual
- Remote Control: Enabled / Disabled
- Transition Mode: Closed / Open
- Peak Shave Mode: Off / Initiated / Auto
- Peak Shave Timed Cycle: Off / Enabled
- Peak Shave Load Demand: Off / Enabled
- Retransfer Mode: Auto / Manual
- Fail to Sync Action: Fail to Interrupted Transfer / Wait for Reset
- Utility Failed during Parallel Operation Action: Auto Retransfer / Wait for Reset

3.5.10. The following control switch functions shall be provided on the Operator Interface panel:

3.5.10.1. Peak Shave Mode -

- **Off** - Peak shaving is disabled. If currently paralleled to the utility in the peak shave mode of operation the system will perform a controlled shutdown (unload, trip, cooldown)
- **Initiate** - Manually initiates the peak shave mode of operation, the generator will start and parallel to the utility supply.
- **Auto -** Enables automatic peak shave operation. Three modes of peak shave are available: timed cycle, load demand or remotely initiated.

3.5.10.2. Peak Shave Timed Cycle - The timed cycle mode of operation is usually used as a convenient means of providing an automatic periodic test. A selector is provided which allows the operator to enable or disable the timed cycle. The start/stop time and day selection (28 day) are programmable, each day may be individually selected

3.5.10.3. Peak Shave Load Demand - The load demand mode of operation is used to offset utility demand charges. The system will automatically monitor the utility import and parallel the generator during periods of high usage to avoid costly peak charges. A selector is provided which allows the operator to enable or disable the load demand mode. The start/stop utility import levels are programmable.

3.5.10.4. Load Control Mode - Two modes shall be provided: base load or minimize import. If the base load mode of operation is selected when the generator is operating in parallel with the utility the generator will load up to and maintain the base load setpoint. If minimize import is selected the generator will assume load until the utility is unloaded to the minimum utility

import load level setpoint.

Note: Two related setpoints are also provided. Peak shave generator output limit, this may be set to limit the generators output while operating in the peak shave mode but will not limit the output when operating in stand alone (standby). Maximum export, this will limit the ability of the generator to supply power to the utility grid. It is common on these systems to have reverse power protection to trip the generator in the event it starts to supply power to the grid; on this type of system the maximum export would be set to zero. The maximum export setting will override the base load and minimum import setpoints.

3.5.10.5. Transition (Closed - Open)

- **Open -** When transferring to the generator supply the utility breaker opens then the generator breaker closes. When transferring to the utility supply the generator breaker opens then the utility breaker closes. This causes a momentary loss of power when transferring to or from the generator supply.

- **Closed** - When retransferring to the utility supply the generator will be automatically synchronized to the utility and the utility breaker closed prior to the generator breaker opening. This allows for a uninterrupted transfer (ie. no interruption to the load). Similarly a uninterrupted transfer to the generator will take place when peak shave operation is initiated.

3.5.10.6. Retransfer Mode Selection (Auto – Manual)

This selector selects the retransfer mode. If manual retransfer mode is selected the system will remain on the generator supply, following a utility power failure, until a retransfer is manually initiated by depressing the manual retransfer initiate push-button. If auto retransfer mode is selected the system will automatically retransfer to the utility supply provided it remains within limits for duration of the retransfer delay timer.

3.5.11. The following parameter setpoint adjustments shall be provided on the Operator Interface panel:

3.5.11.1. Peak Shave Load Demand Start setpoint (0-100% of the generator rating**, can not be set lower than the stop setpoint), delay (1-600sec) - if load demand peak shave is enabled, when the load demand reaches the start setpoint the generator will start and parallel to the utility.

3.5.11.2. Peak Shave Stop setpoint (0-100% of the generator

rating**, can not be set higher than the start setpoint), delay (1-3600 sec) - when operating in the load demand peak shave mode, when the load demand falls below this setpoint the generator will perform a controlled shutdown (unload, trip, cooldown). The controls will bypass the stop delay timer if the minimum import or maximum export level is reached and the load on the generator falls below the zero power transfer setpoint, this is done to prevent unnecessarily tripping the generator on reverse power.

3.5.11.3. Peak Shave Timed Cycle (Day 1-28, Start Time hh:mm, Stop Time hh:mm, 24 hr format, 15 minute increments) - A 28 day clock is programmed into the PLC to allow setting of an automatic exercise cycle, each day may be individually enabled. If timed cycle peak shave is enabled, when PLC clock reaches the start time the generator will start and parallel to the utility. When the stop time is reached the generator will perform a controlled shutdown (unload, trip, cooldown).

3.5.11.4. Exercise Day/Clock Set (1-28 days, Time hh:mm 24 hr format, 1 minute increments) - allows adjustment of “exercise” day / clock (time).

3.5.11.5. Peak Shave Warm-up timer (0-600sec) - When a peak shave start is initiated, the PLC will run the engine unloaded for the duration of this time setting before initializing the automatic synchronizer.

3.5.11.6. Base Load setpoint (25-100% of the generator rating**, can not be set higher than peak shave generator output limit) - when operating in the peak shave / base load mode the generator will maintain operation at the level set, provided the maximum export level is not exceeded.

3.5.11.7. Minimum Import setpoint (+/-100% of the generator rating**) - when operating in the peak shave / minimize import mode the generator will maintain the utility import at the minimum import setting, provided the maximum export and generator load limit settings are not exceeded.

3.5.11.8. Maximum Export (adjustable +/-100% of generator rating**) - this setting will override the base load or minimum import setting, limiting the amount of power which can flow to the utility.

3.5.11.9. Peak Shave Generator Output Limit (50-100% of the generator rating**) - when operating in the peak shave mode the generator’s maximum output will be limited to this setting.

The output will not be limited during stand alone operation.

3.5.11.10. Utility Failed during Parallel Operation Reset mode (Auto/Manual) - In automatic the system will re-sync to a stable utility supply after the utility fail during parallel operation auto resync delay. In manual a parallel gen. fail reset push-button will appear on the alarm history screen, this button must be depressed by an operator before the system will resume parallel operation.

3.5.11.11. Utility Fail during Parallel Operation Auto Resync delay (5-600 sec) - If the utility experiences a transient the utility breaker is immediately tripped and the generator continues to supply the load. If utility failed during parallel operation is selected for automatic reset, the system will automatically reconnect to the utility supply after this delay.

3.5.11.12. Reclose Attempts (1-5 attempts) - Number of times the PLC will attempt to resynchronize to the utility supply. The reclose attempt count must be manually reset (set to 0).

3.5.11.13. Standby Warm-up timer (0-30 sec) - The amount of time the generator runs unload before closing onto the dead bus when the utility power has failed.

3.5.11.14. Retransfer to Utility delay (5-600 sec) - After a utility power failure the amount of time the system waits before synchronizing the generator to the utility supply.

3.5.11.15. Neutral delay (0-10 sec) - When performing an interrupted transfer between to live sources the first breaker will trip, the generator switchgear will remain in this position (both breakers open / neutral position) for the duration of this delay, then the opposite breaker will close. This allows for the bus voltage to decay before closing onto the bus and prevents voltage transients and tripping motor overloads due to out-of-phase closure between the source and the regenerated voltage from motors which are winding down.

3.5.11.16. Fail to Sync Alarm delay (15-600 sec) - the amount of time the controls will attempt to synchronize the generator to the utility, if the generator does not synchronize to the utility within the allotted time a fail to synchronize alarm is annunciated. When the system is attempting to synchronize the generator to the utility supply (peak shave initiated) the generator start will be relinquished and generator will continue to run for the cooldown period. If the system is on the generator supply and attempting to perform an uninterrupted transfer back to the

utility supply further action is determined by the fail to sync alarm action setting.

3.5.11.17. Fail to Sync Alarm action - If “Fail to Interrupted Transfer” mode is selected, the controls will automatically perform an interrupted transfer to return to the utility supply. If “Wait for Operator” is selected, the controls will terminate attempting to synchronize to the utility and wait for the operator to either switch to the interrupted mode of transfer or reset the fail to sync alarm. A fail to sync reset push-button will appear on the alarm history screen, depressing this button will reset the fail to sync alarm, allowing the controls to re-attempt auto synchronization.

3.5.11.18. Ramp Rate (1-100kw/sec) - The PLC soft loads and unloads generators in and out of the system. This setpoint allows operator adjustment of the ramp rate in kilowatts per second.

3.5.11.19. Zero power transfer / unload trip (20-100kw) - This setting allows adjustment of the point at which the PLC trips open the generator breaker when ramping load down on a unit.

3.5.11.20. Max Breaker Trip delay (30-600 seconds) - The maximum amount of time the PLC will wait for the generator to unload to the zero power transfer setpoint. If the generator fails to unload for any reason it will be tripped upon expiration of this timer.

3.5.11.21. Deadband (0 -+/-20kw) - number of kilowatts either side of the setpoints the system must stray before the PLC attempts to adjust the generator output, this will have on effect how smoothly the system maintains load level and the efficiency of the generator.

3.5.11.22. ** % of the generator rating - this is rated output of the generator, the settings are expressed in kilowatts.

Acceptable model will be a ***Thomson Power Systems GCS 2000-DG*** series generator switchgear.