

aksa POWER GENERATION

AKSA POWER GENERATION

Parallel Generators and Synchronization, Generator Power System Design



DIRECTORY

I. OVERVIEW -----	01
II. DESCRIPTION OF PARALLEL CONNECTION SCHEME -----	01
III. ENVIRONMENT FOR INSTALLATION AND USAGE -----	04
IV. STRUCTURE DESCRIPTION AND TECHNICAL PARAMETERS OF THE SWITCH CABINET FOR THE GENERATOR SETS -----	04
V. OPERATING PRINCIPLES OF THE AUTO PARALLEL OPERATION SYSTEM -----	05
1. Synchronize function-----	05
2. Function of auto load distribution-----	06
3. Function of peak regulation(option)-----	07
4. Brief introduction on DSE7510 parallel operation control system made by UK DSE-----	08
VI. DELIXI CDW1 SERIES FRAME-BASED STATIONARY ACB (AIR CIRCUIT BREAKER) -----	11
VII. ADVANTAGES OF THE PARALLEL OPERATION SYSTEM -----	12

Technical Instruction

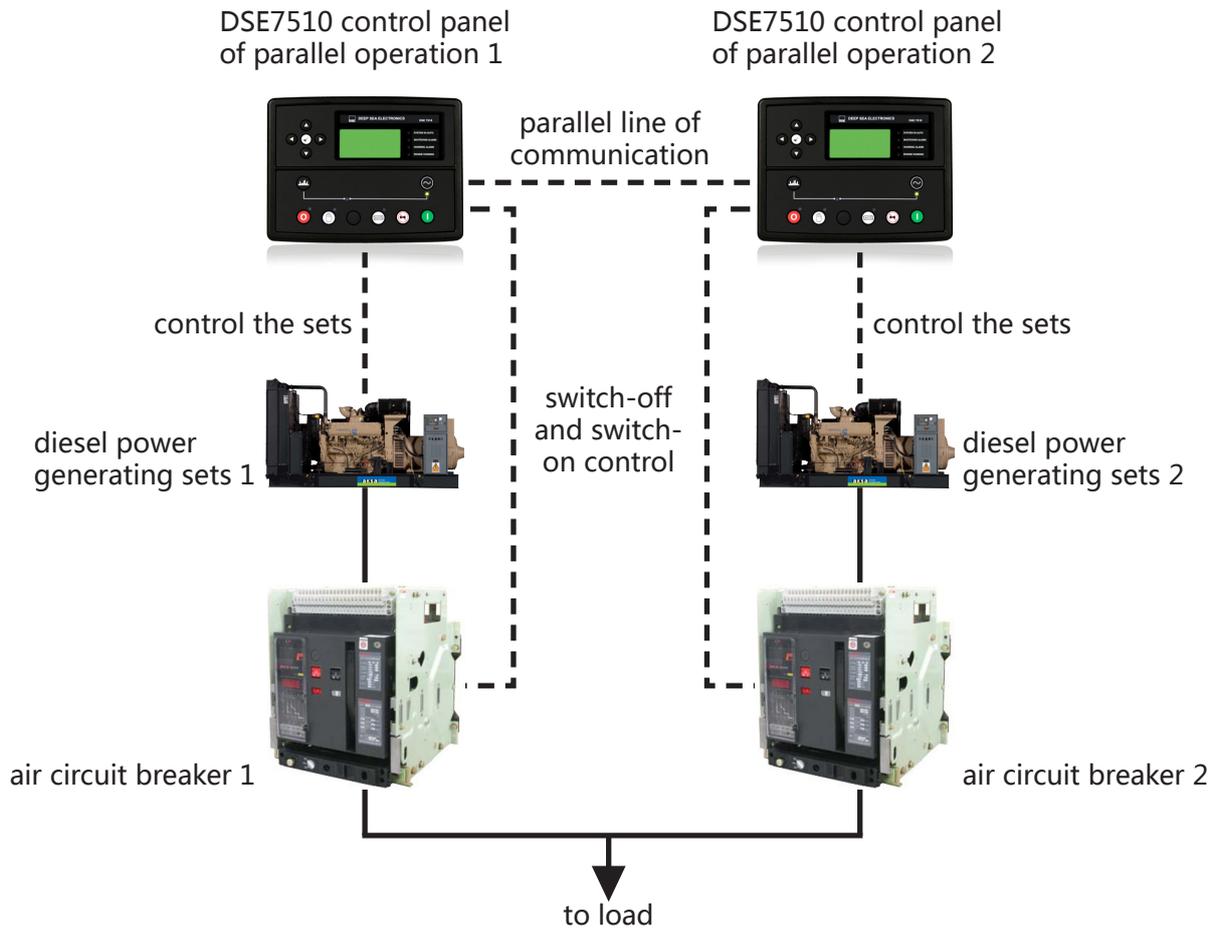
I. Overview

In accordance with the actual situations and the needs of the user, AKSA Intelligent Digital Automatic Parallel Connection System is selected which comes with DSE7510& DSE8610 Parallel Operation Controller made by Deep Sea Electronics plc (DSE). It matches with frame-based stationary ACB Switch and the entire system can function as single machine, double standby and artificial or automatic parallel operation. AKSA Intelligent Digital Automatic Parallel Connection Equipment is specially designed and manufactured for the parallel operation of the diesel power generating sets. This equipment can run in parallel operation of two or more than two diesel power generating sets with electronic speed control device or electronic-controlled fuel injection device. The core components and parts of this equipment consist of deep-sea DSE7510 & DSE8610 control module and auxiliary relay imported from UK, domestic high-quality electric components and the intelligent breakers of domestic or foreign brands. All of them are elaborately designed and meticulously made by professional senior engineers. DSE7510 & DSE8610 Parallel Connection Equipment is characterized by its versatile functions, simple handlings, reliable operation and ease of maintenance.

II. Description of Parallel Connection Scheme

AKSA Intelligent Digital Automatic Parallel Connection System adopts the PLC (programmable logic controller) of the DSE7510 & DSE8610 Intelligent Parallel Generating Set made by Deep Sea Electronics plc (DSE) as the logic control device to control the generating sets and the synchroswitching-in and parallel connection of the low-voltage switches of the output GCB (Generator Circuit Breaker). It is capable of automatically controlling the startup & close-down, parallel and separating brakes of the diesel engine through internal control program and corresponding external control signal and according to the program-set control logic automatically. It can also actualize the power distribution to multiple sets and the synchronous parallel connection inspection. It combines the functions of load distribution, synchronous control, set control into one, having complete functions of sets control, monitoring and protection.

PARALLEL GENERATORS AND SYNCHRONIZATION



*Composition of parallel connection control system

1. DSE7510 & DSE8610 control panel of parallel operation

The master controller with the leading technology in the world is chosen to provide control and protection, automatic & artificial parallel connection, automatic load distribution of active and reactive power and the communication function.

2. Air circuit breaker

The generating sets in parallel connection must be equipped with electrical air circuit breaker and the rated current of the air circuit breaker depends on the output current.

3. AKSA standard cabinet's surface is treated with spraying plastics. Other components include:

high-quality TMY copper busbar, emergency stop switch, failure alarm buzzer and auxiliary relay, etc.

***Sketch diagram of parallel connection control system**

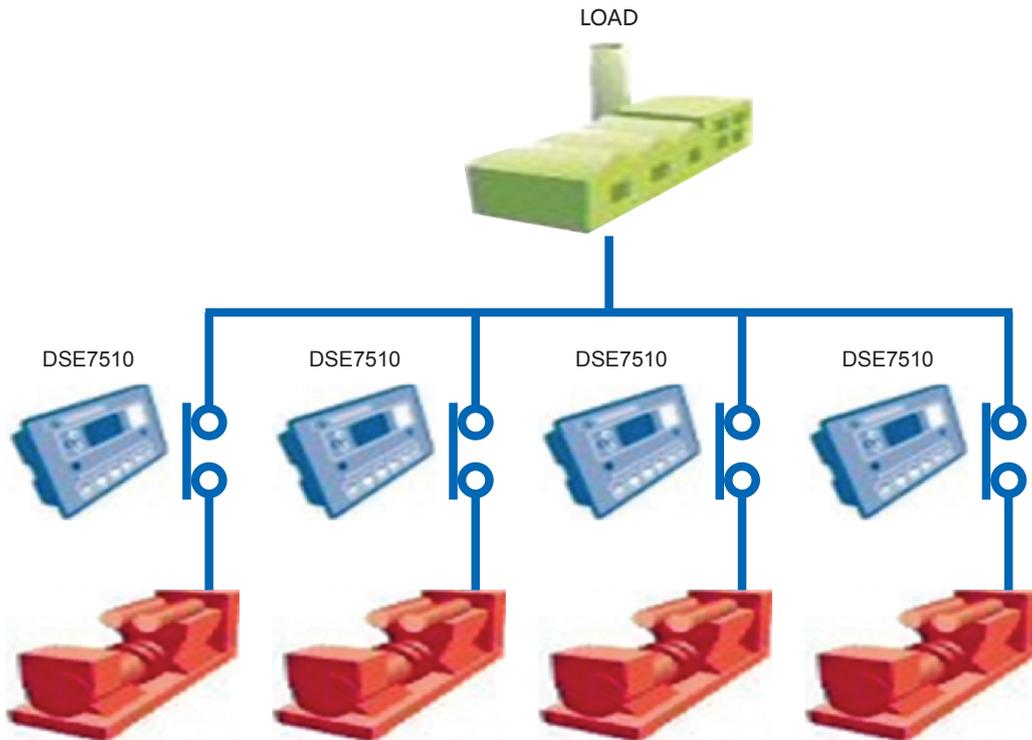


Fig. 1: Sketch diagram of parallel connection among the generating sets

***Function of system protection loop:**

- A: Protection of machine failure
- B: Reverse power protection
- C: Protection of over-current and short-circuit
- D: Protection of over-voltage and low-voltage
- E: Protection of over-frequency and low-frequency
- F: Protection of emergency shut down
- G: Protection of positive power monitoring

III. Environment for installation and usage

- 1.Ambient air temperature: $\leq -5^{\circ}\text{C}$, $\geq +45^{\circ}\text{C}$. (when the preheating arrangement is added, it can be used in environment at $\leq -30^{\circ}\text{C}$ temperature) ;
- 2.Installation site : altitude $\geq 2000\text{m}$;
- 3.Relative humidity : $\geq 90\%$, condensation on the surface ;
- 4.No conductive dust or fluid ;
- 5.No sufficient corrosive gas or vapor which destroy metal or fluid;;
- 6.Occasion without explosion hazards;
- 7.The place where there is no snow or rain;
- 8.Installation condition: the vertical inclination of the cabinet with no more than 5 degrees.

IV. Structure description and technical parameters of the switch cabinet for the generator sets

1. Structure description

- a)The framework adopts AKSA standard cabinet with surface treated with spraying plastics
- b)TMY copper busbar is adopted and designed according to full load. The cable at the end of the generator sets is connected to the main switch through the upper and lower end of the cabinet and the output end of the main switch there retains a connecting copper busbar.

2.Technical parameters

- | | |
|---|---|
| a)Voltage of the generator sets : | 220VAC~480VAC ; |
| b)Power of a single set of the generator sets : | 90~2000KW ; |
| c)Frequency : | 50HZ 或 60HZ ; |
| d)Wiring mode : | Y-connecting methods / three-phase four-wire ; |
| e)Difference of phase synchronization : | $5\sim 10^0$, generally set at 10^0 ; |
| f)Deviation of load distribution : | $\pm 5\%$ adjustable ; |
| g)Reverse power action : | 0.5~20% adjustable ; |
| h)Positive power action : | "NO" 20~100% adjustable
"OFF" 0~80% adjustable |



Fig 2: Switch cabinet for generator sets

V. Operating principles of the auto parallel operation system

The control system of the parallel operation cabinet adopts the PLC (programmable logic controller) of the DSE7510 & DSE8610 Intelligent Parallel Generating Set made by Deep Sea Electronics plc (DSE) as the logic control device and the low-voltage switch cabinet, which is capable of automatically controlling the startup and closed-down of the diesel engine through internal control program and corresponding external control signal according to the program-set control logic automatically. It combines the functions of load distribution, synchronous control, unit control into one complete system. It has functions of unit control, monitoring and protection.

This parallel operation system can automatically detect the three-phase output power (voltage and current) of the generators. It can output DC control signal to conduct real time adjustment to the AVR systems and the electronic fuel speed control systems of the generator sets so as to control the output power of each generator set and ensure the balanced distribution of active and reactive power.

1. Synchronize function

This parallel operation system adopts the DSE7510&DSE8610 control module made by UK DSE as the master control unit. It includes the functions of generator sets control, synchronization control and load distribution. It can internally and automatically conduct contrastive analysis according to the parameters as set by the program through detecting the three-phase wire voltage, frequency signal of the generator set and the three-phase wire voltage, frequency signal of another generator set to be in parallel connection. At the same time, this parallel operation system can output a DC signal to act on the engine speed-controlling system as well as alternator regulating voltage system and to adjust the rotating rate of the generator sets, making the phase and the frequency of the voltage signal to achieve the consistent and synchronic requirement. Then the system sends out the synchronized signal to act on the circuit breaker which allows switching. When the switching is on successfully, the parallel operation is completed and then the load distribution of the generator sets can be controlled.

This parallel operation system can automatically detect the three-phase output power (voltage and current) of the generators. It can output a DC speed regulation control signal to act on the electronic speed regulation control system of the engines accordingly to control the frequency of rotating speed of the generator sets. In this manner, the fuel consumption is under control so that the balanced power of the generator sets is controlled. Meanwhile, the internal synchronous tracker is adopted to detect the frequency, phase angle and voltage between the standby generator sets and the generator sets to be in parallel connection, during which, by constantly contrasting the internal set programs and the parallel connection parameters, via the calculation by internal CPU, the DC voltage-regulation and speed-regulation signals are output to act respectively on the AVR (automatic voltage regulation system) of the generator sets. The EFC (electronic fuel control system) of the engines adjusts the output voltage of the generator and the rotating speed of the engine so as to meet the synchronous requirements (1. the effective value and wave form of the generator's voltage must be the same; 2. the voltage phase of the two sets of generators must be equal; 3. the voltage frequency of the two sets of generators must be equal; 4. the phase sequences of the two sets of generators must be equal) and control the switching-on and parallel connection of GCB (generator circuit breaker).

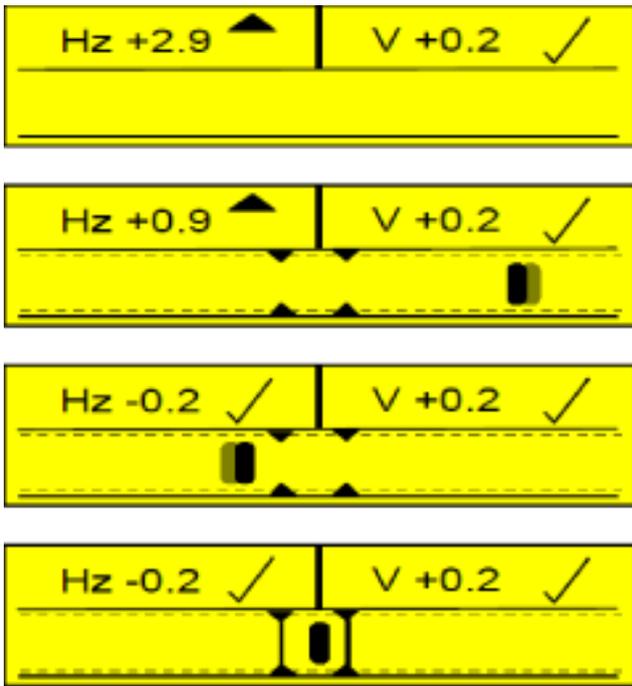


Fig 3: Display of synchronous mode

2. Function of auto load distribution

When parallel connection of two or more sets is completed, the sets begin to operate with load. When the internal power distribution unit of the UK DSE7510&DSE8610 control module acts on the speed regulation system, it conducts the load distribution according to the proportion as set by the program in advance.

The control system of the parallel operation cabinet adopts the built-in power distribution control unit of UK DSE7510&DSE8610 control module as the full automatic load control which can detect the three-phase output power (voltage and current) of the generators. It can communicate with various controllers and calculate the interior power and then output a DC speed regulation control signal to act on the speed regulation control system of the engines accordingly to control the rotating speed of the generator sets. In this manner, the fuel consumption is under control so that the output of the active power of the generator sets is controlled and the balanced

power among the generator sets is maintained. At the same time, the control module can output a DC voltage regulation control signal to act on the voltage regulation control system of the generator sets so as to control the output of reactive power of the generator sets by controlling the voltage and to ensure the balanced power among the generator sets.

UK DSE7510&DSE8610 control module within each parallel operation cabinet can transfer the load level information of every single set from one another via its parallel connection communication through the parallel lines. It can automatically control the rotating speed of the generator sets and can automatically distribute the load according to the proportion as set in advance.

Meanwhile, UK DSE7510&DSE8610 control module is equipped with the function of monitoring the positive power and protection of the negative power. It can setup the maximum output power of the sets manually, protect the reverse consumption power (reverse power) and provides a complete power protection for the diesel generator sets.

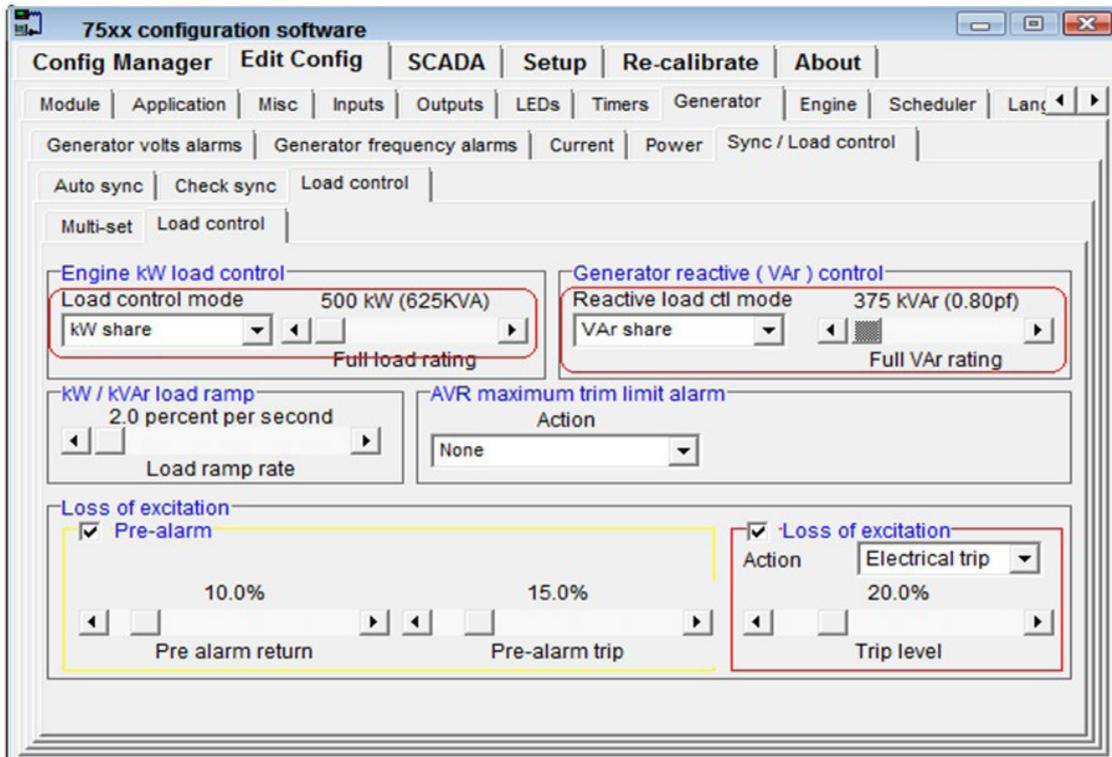


Fig 3: The rate power and the reactive power of the generator sets setup by SE7510

3. Function of peak regulation (option)

When the load of two or more sets in parallel operation varies, the set number of the generator sets can be increased or decreased according to the total load. The generator sets can automatically start up or close down based on the load level, resulting in the most economical manner for the sets to work.

When one of the sets goes into normal working operation, UK DSE7510 parallel operation control system can scan the change in load level. If the load exceeds 80% (adjustable) of the power value of the set, UK DSE7510&DSE8610 parallel operation control system will send a signal to start up the next generator set. When such set is started successfully, UK DSE7510&DSE8610 parallel operation control system can detect the voltage level, the frequency variation and the phase offset of each generator set. When the above values of the two generator sets have deviation that is larger than the setup value in parallel operation, UK DSE7510&DSE8610 parallel operation control system can adjust the operating parameters of the generator sets. When the deviation of above values is adjusted to the right range, the signal is sent to switch on in parallel operation and the sets will operate in parallel connection. At this moment, the built-in load distributor of UK DSE7510&DSE8610 will start to work, automatically detect the loading ability of each set and automatically distribute load to the set according to load level so as to balance the loading of the generator sets.

When two generator sets work in parallel operation, UK DSE7510&DSE8610 parallel operation control system can scan the change in load level. If the load is lower than 30% (adjustable) of the full

power value of the first set, the built-in load distributor of UK DSE7510 & DSE8610 parallel operation control system will transfer all load to the first set and send out a disconnection signal automatically when this process is complete. The parallel operation between the two sets is disconnected and the disconnected sets without load will close down and go to a stand-by situation after cooling in given time.

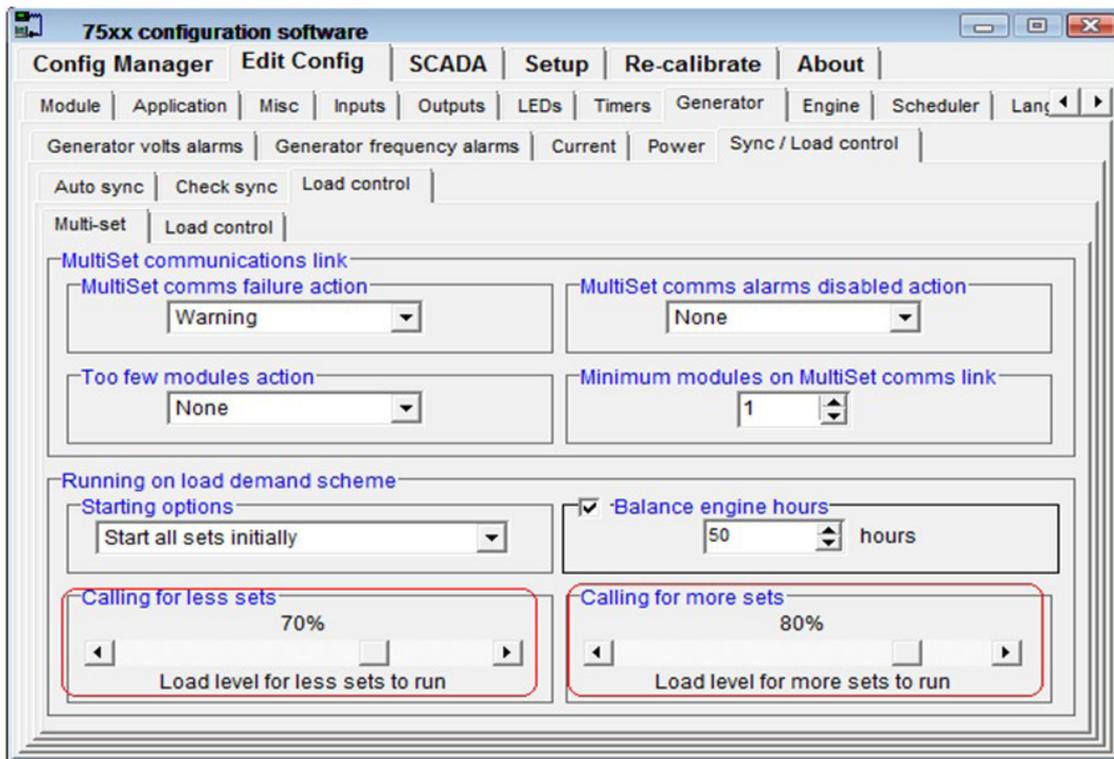


Fig 5: Function of peak regulation of DSE7510

4. Brief introduction on DSE7510&DSE8610parallel operation control system made by UK DSE:
 DSE7510&DSE8610 is the automatic engine control module that can self boot and stop the engine to indicate the operation status and the failure situation. The indicating method is to display on the LED of the front panel and on the flashing LED. The selected operational procedures, the timing device and the alarm can be changed by the user. This kind of modules has the function of the synchronization and load distribution, including the auto synchronous control by built-in synchronometer, the conformity of the voltage and frequency as well as the device from switching-on to no-power electrical drainage. The modules can directly offer various flexible output, allowing connection with the most general speed regulator and Automatic Voltage Regulator (AVR).

UK DSE7510&DSE8610 is a LCD control module for auto monitoring the utility power, featured by remote control, remote metering and remote communication and also the control module for auto start, synchronization and load distribution. It enables conducting the measurement of various electrical parameters and large-screen liquid crystal display with the functions of manual and auto parallel operation and auto load distribution among every generator set according to automatically set proportion.

UK DSE7510&DSE8610 can monitor the utility power supply (effective AMF function). It can start the generator sets when the utility power falls below the limit and will automatically switch over the load when utility power fails. In case of the failure of the sets, it will shut down the generator sets automatically and emergently, indicating the real time cause which leads to the failure of the generator sets by flashing common alarming LED light, displaying the specific failure status through the LED on the panel.

Since microprocessor design is applied to the module of UK DSE7510&DSE8610, it can satisfy the most complicated technological requirements as set forth by the manufacturers. The module is designed for auto start, normal operation and auto stop for the generator sets, display of various parameters, operating status and failure situation of the generator sets. When the sets shut down automatically due to the failure, the LED can display corresponding failure items. The internal parameters within the system can be configured through P810 interface to connect with PC. The module is provided with the RS232/RS485 communication ports (alternative), which can realize the remote communication completely according to the user's requirements and at the same time, can offer real-time diagnosis to the users. The module is featured by its compact size and elegant appearance.

Working mode of the controller

The front panel of the module has the mode for stop, auto and manual buttons and each mode is provided with LED indicator.

When the switch is at OFF position (stop or reset mode), the direct current is disconnected with the module. The relay runs and the alarming output closes down.

When the switch is at AUTO position (auto mode), the system can self start after receiving start signal in case of utility power failure.

When the switch is at MANUAL position (manual start mode), press the green start button, the fuel electromagnetic valve acts and the motor begins to start.



Fig 5: Operating instructions for the panel of DSE7510 controller

PARALLEL GENERATORS AND SYNCHRONIZATION

1. The option of CANBus can be used for the “environmental protection” engine management system as defined in the industrial standard, J1939, SAE, offering engine protection and instruments detection without additional sensors;
2. Multiple sets of communication port can be selected, allowing connection with up to 16 sets of generators, attached with non-power busbar control for distribution of active and reactive load, which can start or stop the sets within the system according to the load requirement so as to actualize the full auto parallel operation;
3. Through RS232 end to extend to PC. When using self chosen RS232, the modem data unit of RS232 can be connected to personal computers via PSTN line or GSM network (when one proper modem data unit is used). The modules can also use GSM SMS to send the SMS to the cell phones of the users so as to notice the system to alarm;
4. Modern technology is used to realize the functions of auto synchronization and load distribution;
5. The alternative RS484 Modbus output adopts industry standard communications protocol and allows the complete system to be integrated into the new and existing building management and control programs BMS;
6. The front panel featured with PIN password security which can be programmed to choose the tripping points and the timing device and allows changing the preset value of the modules on site;
7. The clear engine diagnosis information can remove the devices needed for service and the confidential diagnostic indicator (when connecting with J1930 engine);
8. The built-in and pre-set running program can be configured as self start or stop at certain duration in each week or each month;
9. The LED display based on four lines of words can provide the “clear at a glance” failure diagnosis, instrument detection and the operation status;
10. Multiple LED languages (Chinese, English, French, Spanish and German etc) are available;
11. Auto and manual operating modes;
12. The measurement range of the voltage can reach 22, 000 volt, which can be reached by using the transformer input VT’ s) ;
13. Nine auxiliary inputs can be set up to connect with external sensor;
14. Five outputs can be set up off the “combined into one cabinet” solution;
15. Independent button for generator load switch offers the “combined into one cabinet” solution.

VI. DELIXI CDW1 Series Frame-based Stationary ACB (air circuit breaker)

The air circuit breaker (ACB) is also called framed-based circuit breaker and is a kind of electrical appliance of the mechanical switch that can connect up, bear and disconnect the current under normal circuit condition. It can also connect up, bear for sometime and disconnect the current under the defined abnormal circuit condition.

CDW1 Series ACB

Function introduction on CDW1 Series ACB: this ACB is laid out in vertical form. The left and right lateral plates of the contact head system and the momentary excess current release are installed on one piece of insulation board. The arc extinguishing system is installed upside, the operating mechanism can be installed at the front or at the right side with "OFF", "No" indicators and the button for manual disconnection. The shunt release is installed at the left upper and the under voltage release connecting to the semi axle of release is installed at the back. The rapidly saturable current transformer or the current and voltage transformer is around the lower busbar. The under-voltage equipment for delay time and the thermal relay or the semiconductor release can be respectively installed at the bottom. . CDW1-2000 Circuit Breaker is laid out in vertical form and the framework is comprised of underframe, lateral plates and cross beams. The contact head system for each phase is installed on the underframe and the arc extinguish chamber is installed upside. The operating mechanism is at the right front of the circuit breaker, connecting to the contact head system via the main axle. The electrical operating mechanism combines the square axle with the mechanism into one, being installed at the bottom of the circuit breaker for the usage of accumulation of energy or direct closure of the circuit breaker. The closure after accumulation of energy is assumed by energy-releasing electric magnet. An anti-rebound mechanism is installed at the upper of the left lateral plate to prevent the circuit breaker from bounding when it is disconnected. Various over current releases are installed beneath the circuit breaker according to different requirements and the over-voltage and shunt releases and the electrical operating control system are installed at the left side, of which the over-voltage and shunt releases are connected with the magnifying mechanism via the release so as to reduce the tripping force of the circuit breaker. 12 pairs of auxiliary contact heads is for the user to connect the secondary loop; the indicating signs to display the working position of the circuit breaker "1" and "0" and the indicator of "accumulation of energy" are on the panel, together with the buttons "1" and "0" (both pressed) for switch-on and switch-off. CDW1-2000 Series Circuit Breaker is attached with a manual operating handle in the front.



CDW1 Series Intelligent and ACB applies to the distribution network with AC 50 Hz, the rated voltage of 380V and 660 V and the rated current of 200A-6300A and it is mainly used to distribute the electricity energy and to protect the circuitry and equipments from the hazards of failures such as the over load, undervoltage, short-circuit and the single-phase grounding; this circuit breaker is provided with multi smart protective functions and can actualize selective protection, the action is accurate, the unnecessary power off can be avoid and the power supply reliability can be increased. Universal Circuit Breaker is used to distribute the electricity energy and to protect the circuitry and the power supply equipment from the hazards of over load, undervoltage, short-circuit and so on, and can be used for non-frequent conversion of the circuits under normal conditions. In the network

of AC 50 Hz and the rated voltage of 380V, the circuit breaker beneath 1250 A can be used for the protection of the over load and short-circuit of the motors and can be used for non-frequent conversion of the circuits under normal conditions.

VII. Advantages of the parallel operation system

1. Two or more sets of generators in parallel operation are equal to one set of large power generator to supply the power the load and can balance the load over various circuits and supplement the peak to valley mutually, and can decide how many sets should be started according to the load level (when the sets are at the operating condition by 75% of the rated load, the fuel consumption is minimum) so as to save the diesel and reduce the generating cost.

2. The uninterrupted power supply (UPS), the operation exchange among the generator sets can be actualized to ensure the normal production of the plants; when the sets are converting, the standby generator sets can be merged into the operation system; after all the load can be transferred to the standby sets that are already running, the former operating sets can stop, during which it no need to cut off the power.

3. When two or more sets are in parallel operation and the load increases all of a sudden, the two or more sets can share the current impact evenly, therefore, the mutual aid and mutual supplement of the load and the among each set have higher shock resistance to reduce the impact to each set; under the situation of larger load impact, two or more sets in parallel operation can bear larger impact than that on the single set, at the same time, two sets in parallel operation can stabilize the voltage and the frequency and prolong the service life of the generator sets.

4. Whether the single set operation or the dual sets in parallel operation can be decided according to the different amount of electricity utilization so as to avoid the waste caused by the load operation of two or more sets and the risk of the single set operating under over loading.

Note : For details, please refer to the system diagram of parallel-sets operation and the technical parameters of the controller.



AKSA POWER GENERATION (CHINA) CO.,LTD

NO.19 Tongjiang North Road, Changzhou New District, Cahngzhou, China
T:+86 (0) 519 851 50 205 F:+86 (0) 519 851 50 130
aksa@aksa.com.tr www.aksa.com.tr