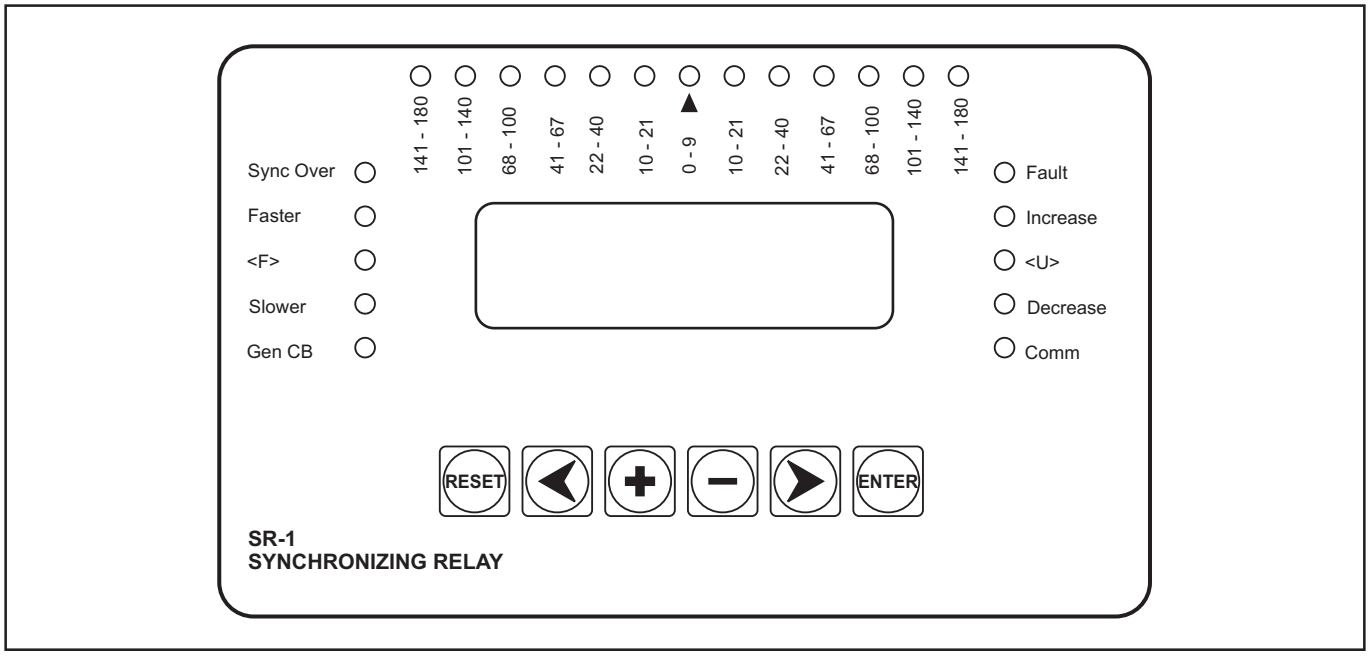
Functional Range

SR 1 (Synchronizing Relay)



C&S electric

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Contents

1 Introduction and Application

Synchronizing Relay Type SR1 provides automatic as well as manual functions for the synchronizing of generators. It monitors difference between voltage/frequency of Busbar and generator and actuates AVR (Automatic Voltage Regulator)/Governor of generator in order to bring the voltage/frequency difference within user prescribed limits.

SR1 takes into account the circuit breaker [CB] delay and issues closing command at such an instant that when CB actually closes contacts, the phase difference is less than 3 degrees.

The SR1 offers the following functions:

- Synchronization of a generator to its reference Bus bar
- Dead bus operation.
- Kicker pulse control.

Controlling output is available in terms of Potential free contact / voltage / current loop or any combination of them. For various types of controlling output combinations, please refer to section -14

The man-machine interface is designed to offer ease of operation and parameter setting, and a clear view of the ongoing processes. It consists of a synchroscope, an alphanumeric display, annunciation LEDs and soft touch keys arranged aesthetically on the front panel.

The SR1 is used for bringing a running generator into synchronism with the system busbar i.e. other already running generator(s). The relay will ensure that the generator and bus are within programmable voltage/ frequency difference ranges, and then issues a close command to the CB. The breaker closing time is taken into account in this process. See the Block diagram in section 13.1.3 for SR1 arrangement.

2 Features

- 16-bit Microcontroller based automatic synchronizing relay
- LED Synchroscope
- Accurate synchronization to a phase

  difference of less than ± 3 degrees.
- Three types of control for voltage / frequency Correction are available:

  a. Potential free contact,

  b. Voltage (± 1V/ ± 3V/ ± 9V/ 0-5V),

  c. Current (4-20mA).

User can choose any combination of these options.

- Proportional as well as Adaptive control. for governor & automatic voltage regulator
- A user friendly MMI
- Wide selectable setting range with fine steps.
- Password security for parameter setting.
- Automatic as well as manual synchronizing mode of operation
- The synchronizing control is blocked when the closing command is issued and remains blocked if the phase difference is less than a user defined limit.
- Hooter assignment on different faults

3 Design

3.1 Connections

Please refer to Section 13.1.2 for connection diagram.

3.1.1 Auxiliary Supply

Auxiliary supply is connected across terminals 21-22. It accepts a wide voltage range between 20V DC to 360 V DC and 25VAC to 270VAC.

3.1.2 Analog Input Circuits

The single phase voltage of bus bar is connected across terminals 1-2 and the generator voltage is connected across terminals 3-4. The voltages so acquired are galvanically isolated, filtered and finally fed to analog – to – digital converter for digital processing.

3.1.3 Output Relays

SR1- has three output relays. Functions of these output relays are described in the Table 1 shown below.

No.	Description	Function
1	Hooter/Alarm	Actuate Hooter/Alarm
2	Synch Over	Issues command to Load Balancing units
3	Generator Circuit Breaker	Issues command to CB of generator

Table 1: Output relay description

The hooter relay assignment feature is available in the MMI. There are seven types of faults on which Hooter relay can be configured. On pressing RESET key Hooter relay will de-energize but the fault LED will remain ON while fault lasts.

3.1.4 Output Control Circuits

Five modes of control for voltage / frequency correction are available. These are Potential free contact, Analog output Voltage (± 1V/ ± 3V/ ± 9V/ 0-5V) and Current (4-20mA). User can choose any combination of these options at the time of ordering. Please refer to section 14 for ordering information.

3.1.5 Potential free Contact: (Option 1)

In this mode N/O contacts of relays for controlling voltage / frequency are available. The operation is described in the following table:

No.	Description	Function
1	Governor ⇧	Issues command to governor to increase freq of generator
2	Governor ⇩	Issues command to governor to decrease freq of generator
3	AVR ⇧	Issues command to AVR to increase voltage of generator
4	AVR ⇩	Issues command to AVR to decrease voltage of generator

3.1.6 Analog Output: (Option 2)

This option is used where the AVR / Governor uses analog inputs for biasing. The choices of biasing voltages are: ± 1V, ± 3V, ± 9V and 0-5V. When the current output is used, the current at output terminal varies linearly with error, in range of (4-20mA). Any combination of these correction control outputs is available in SR1.

3.1.7 Discrete Inputs

There are two optically coupled discrete inputs. One is Start Sync & other is Dead Bus Enable. The Start Sync input comes from Automatic Mains Failure [AMF] relay. AMF relay issues this signal when voltage and frequency of generator are within prescribed band. It's an optional input which user can bypass simply by shorting this input by a simple wire. Second DI is for Dead bus enable. Detection of dead bus bar is done by a single-phase measurement.

Note: As SR1 measures single phase voltage an additional check of the two other phases is essential before using dead bus function.
These digital inputs namely Synch Start and Dead Bus Enable are connected across terminals 29-31, 30-31 respectively.

3.1.8 LCD Display

There is a large back-lit LCD display having four lines of twenty alpha-numeric characters to display voltage, frequency, faults, setting parameter names and values etc.

3.1.9 LEDs

There are 23 LEDs for annunciation. The synch scope which has 13 LEDs displays phase difference between bus bar and generator. Remaining LEDs are for Freq Increase, Freq decrease, In-band frequency, Voltage Increase, Voltage decrease, In-band voltage, Generator CB, Synch Over, Fault and Communication. The functions of these LEDs are described in the Table 2.

LEDs	OFF	ON	FLASHING
Sync Over	Sync Over Relay Open	Sync Over Relay Closed	X
Faster	No Increase Signal to Gov.	Governor Inc Signal active	Gov. Inc. Section Unhealthy
<F>	Freq. Diff. not in User Settable Band	Freq. Diff. in User Settable Band	X
Slower	No Dec Signal to Governor	Governor Dec Signal active	Gov.Dec Section Unhealthy
Gen CB Open	Gen CB Relay Relay Closed	Gen CB	X
Fault	No Fault	Fault	X
Increase	No Inc Signal to AVR	AVR Inc Signal active	AVR Inc Section Unhealthy
<U>	Volt. Diff. not in User Settable Band	Voltage. Diff. in User SettableBand	X
Decrease	No Dec Signal to AVR	AVR Dec Signal active	AVR Dec Section Unhealthy
Comm.	No Comm.	Comm. On	Comm. On

Table 2: Function/Indication of LEDs

3.1.10 Front Plate

The front plate is aesthetically designed and ergonomically laid out with a row of 13 LEDs at the top, two columns of five LEDs on either side of a large LCD panel in the center and a row of keys just below it.

3.1.11 Keypad

The user-friendly interactive MMI has six soft-touch keys and the LCD as described above. The RESET key provides reset function to relay. Other five keys are used in edit operation. The keys are "<", "+", "-", ">" and "ENTER". The keys marked "<" and ">" are meant for backward and forward scrolling respectively.

Data or function is selected by pressing "ENTER" key. The keys marked "+" and "-" are used for decrementing and incrementing selected parameter value.

4. Synchronizing operation

4.1 Synchronizing modes

SR1 operates in one of the three selectable modes described below. Operating mode can be selected from the menu using keypad.

These three modes are:

- Auto
- Manual
- Test

Auto Mode-

In Auto mode the correction of voltage and frequency is done automatically after receiving 'Start Sync' command; CB is also closed automatically after taking into account the CB closing delay. This ensures that CB contacts close when phase difference is within 3 degrees and that the voltage and frequency are within the specified band.

SR1 issues correction commands (signals) to AVR in order to bring voltage within band. Similarly it controls the governor to bring frequency of the generator within the set band; thereafter it operates the CB and Sync Over relay to effect synchronization within the set range of phase difference.

Manual Mode –

In the manual mode, relay does not send correction signal to AVR / Governor to bring the voltage / frequency within the set band. For correction of voltage / frequency, manual correction is applied. For this '+' / '-'keys are used for increasing / decreasing voltage/frequency of generator through AVR /Governor respectively. When the voltage and frequency fall within set range, SR-1 issues a command for CB and Sync Over relays, within the set range of phase difference.

This output can be utilized for closing the CB through another set of contacts for manual synchronization.

Test Mode-

In the test mode relay performs all the automatic functions as in auto mode except CB closing, which remains blocked in this mode.

4.1.1 Synchronization of SR1

a) The relay uses one phase of generator and corresponding phase of bus bar for the measurement of voltage difference, phase difference and frequency difference. These are the basic parameters of synchronization. Synchronization is started when 'Sync Start' contacts are activated by shorting contacts (29-31) provided for this purpose.

b) SR1 measures TRUE RMS voltage and frequency of Bus as well as Generator and sends control (increase / decrease) pulses to governor until frequency is within the specified Δf band and greater than the bus bar frequency. (This will ensure that the generator under control will not experience reverse power, when synchronized and connected to the Bus.)

c) It also compares the two voltages and sends control pulses to AVR (increase / decrease) until voltage is within the specified ΔU band.

d) When the voltage and frequency of generator both come within band, SR-1 identifies the instant at which to close contacts, based on present phase difference & CB closing delay; This ensures that phase difference is within set limits at the instant of actual closure of circuit breaker contacts.

e) There are thirteen LEDs arranged horizontally above the LCD. The LEDs start glowing in sequence in accordance with the rate of change of phase difference (As shown in Fig:2).

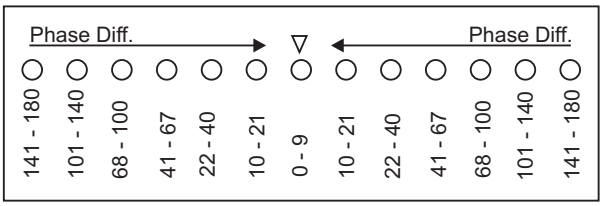


Fig: 2

f) In the Synch-check mode Relay executes the complete synchronization process but does not close the CB. It also takes into account the CB closing delay. It lights up central dot (LED marked by ▼ also called the NULL point) at the instant CB is supposed to be actually closed. If the moving dot arrives at NULL when the dot marked by ▼ lights up then synchronizing operation is going satisfactorily and it would be safe to perform CB closure.

g) SR1 immediately releases the CB relay if voltage, freq or phase goes out of the set band. It will try to resynchronize the generator until the synchronizing time is over. In that case it will issue a Sync Failure fault. Synchronizing time is calculated by the two parameters in MMI i.e. Synch Attempt and Synch TimeOut. For example if Synch Attempt=2 and Synch TimeOut =5min, then SR1 will try to synchronize the generator within 10min (2* 5min).

4.1.2 Dead bus operation

The SR1 relay can be programmed to operate in dead bus modes. Selection is made through interactive MMI; the settings are as follows:

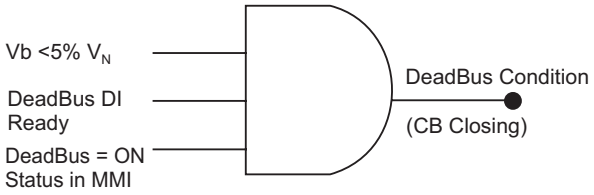
For dead bus operation set DEADBUS = ON

- **Dead Bus Conditions**

  A dead bus condition is identified when the bus voltage (Vb) is less than 5% of V_N, Dead Bus enable DI is ready and in MMI DEADBUS STATUS = ON. When a dead bus is detected, CB Closing command is issued immediately.

Under Dead Bus Condition two additional parameters will come into picture

a) V-NL : -→ 100% to 115% of VN



b) F-NL : -→ 100% to 105% of FN

When SR1 closes CB onto the bus, it controls governor and AVR to adjust frequency to F-NL and voltage to V-NL.

4.1.3 Phase difference

At the instant of synchronism the angular difference of the two systems should be nearly zero, otherwise unwanted load inrushes occur. Theoretically the angular difference can be regulated to zero by very slowly adjusting the speed regulator but in practice a slight frequency difference between the systems is accepted in order to minimize the time required for synchronization. In such cases the angular difference is not constant but changes with time. How fast it changes depends on frequency difference Δf. Larger this value, faster this change.

If $\Delta f=0$, phase difference will not change at all. This is also the reason why kicker pulse is provided when Δf is very small. Kicker pulse slightly increases Δf so that synchronization is achieved within a reasonable time.

By taking the CB operating time into consideration, a lead of the starting impulse can be calculated in a way that synchronism takes place at the exact time when both systems are in angular conformity.

Following thumb rule is generally used:

Where large rotating flywheels are involved, the frequency difference of the two systems should possibly be low (<=0.1Hz.) because of the very high load inrushes at the instant of synchronism. When small flywheels are used, the frequency difference of the systems can be higher.

4.1.4 Function of Synchroscope

A set of 13 LEDs represents a phase difference. LED displays a momentary phase difference between the Bus bar and Generator. During a normal operation, only one LED is lit. The position of LEDs simulates an actual phase difference ranges shown on front plate of the relay. The clockwise movement of the lit LED's indicates higher GEN frequency than BUS frequency and vice versa.

For example, if the bus frequency is 0.1 Hz below generator frequency then generator phase leads bus bar phase and the phase angle changes by 360° in 10 (=1/ 0.1 Hz) seconds. Thus phase difference changes at a rate of 36° per second.

Therefore it will take 10 seconds for the glow of LEDs to shift from left to right extreme.

It also shows that closer the two frequencies, longer will be the time to attain desired phase angle. If the frequencies are very close together, e.g., 0.001Hz, then it can take as much as 1000 seconds to synchronize. If the frequencies are equal, then possibility of synchronization is very remote. Hence if the frequencies are too close, Kicker pulses are applied in order to minimize time to synchronize.

If generator frequency is less than that of bus bar, then LED light will appear to move in the opposite direction.

If the two frequencies are exactly same, then only one LED glows and it glows steadily. The phase difference under such condition is within the band specified for that LED. For example, if LED number 5 glows, then phase difference between the two voltages is between 22^0 and 40^0. When the two machines are in synchronism, the LED at the centre which is marked '0^0- 9^0' glows steadily. The central LED, glows green. When CB is operated by SR1, we should expect green LED to glow, and keep glowing. In test mode, CB is not allowed to close, or when the CB is disconnected, the position of the glowing LED will tell whether the machine would have been correctly synchronized.

4.1.5 Logic of CB closing

The actual phase angle at which the circuit breaker closing command is issued through energization of the CB relay, is determined by setting of the variable CB Delay [T_{CB}]. This variable is set to be equal to the closing time of the circuit breaker once the close coil is energized. The value of T_{CB} may be set between 10 msec – 400 msec.

On the basis of present instantaneous phase difference, time remaining to close CB is calculated:

$\Delta t = (1/\Delta f) - (T_{CB} + Tr) - \theta / (360^* \Delta f)$

T_{CB} = CB delay time as set

Tr = External relay operating time

θ = present instantaneous phase difference

Δf = measured frequency difference $|f_G - f_B|$

So CB closing command is issued before the actual zero degree phase difference, depending on the CB delay and frequency difference. This effectively advances the angle at which the closing command is issued. This has been explained in figure 3.

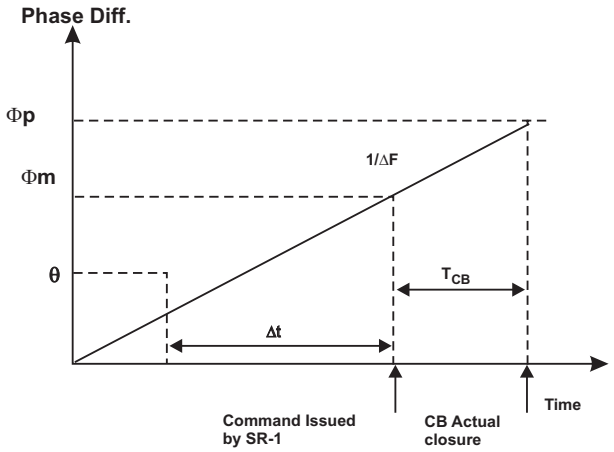


Fig. : 3

- Measured Phase Difference (Φm) is the angle at which SR1 issues CB command (i.e. excluding the CB operating delay).
- Projected Phase Difference Angle (Φp):- It is the Phase Diff at the instant of actual CB closure.
- $\Phi p = \Phi m + (360^* \Delta F * T_{CB})$

SR-1 identifies the CB closing command instant from the measured present rate of change of phase difference and CB closing delay time. Thus it is guaranteed that the contacts of the circuit breaker close at the time of phase coincidence within a tolerance of ±3 degrees. With a small frequency difference or a small circuit breaker time delay, CB closes when the angular advance is low.

The maximum angular advance possible is limited to 45 degrees. If an angular advance is calculated larger than 45 degrees, CB is not switched but waits for a more exact "frequency match".

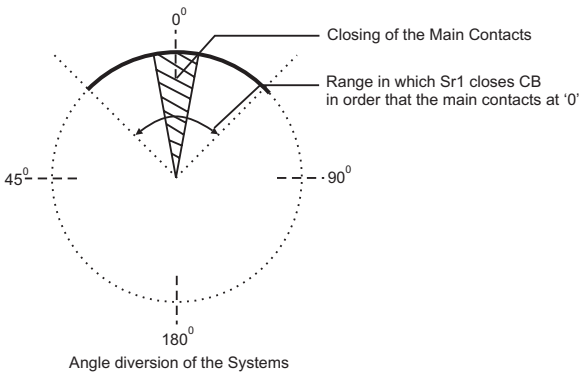


Fig: 4

The relation between CB closing time and Slip frequency is shown in the following graph.

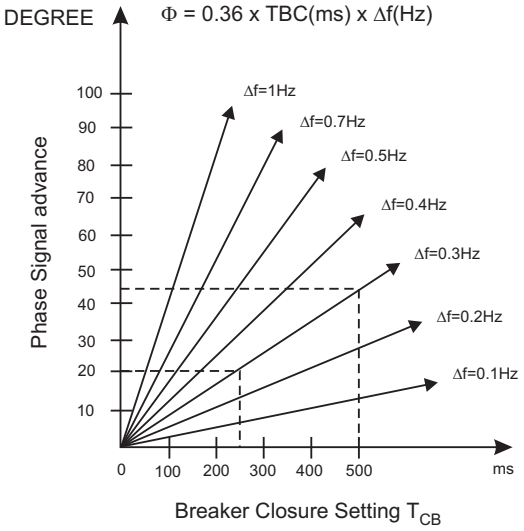


Fig: 5

SR1 will display the CB/Slip Error if settings of Slip Freq Diff and CB time don't meet the advance angle of 45 degree.

Once the closing command is issued CB relay remains energized as long as the closing conditions are met.

5 Voltage Regulator Operation

The voltage regulator control of the SR1 operates when the voltage of the generator is above or below the bus voltage by more than the set operational tolerance. That is:

$U_G < U_B$ OR $U_G > U_B + \Delta U$

Where : U_G = The Generator Voltage

U_B = The Bus Voltage

ΔU = The voltage control bandwidth

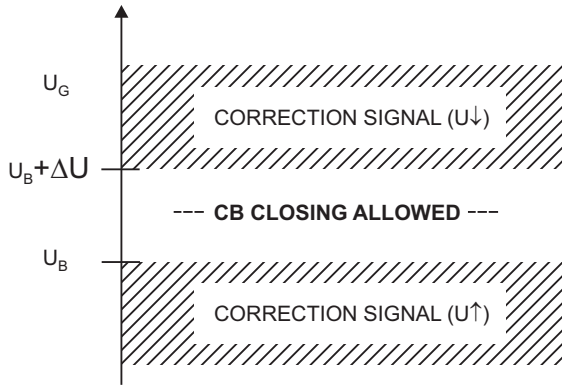


Fig.6 : Voltage Regulator Operating Characteristic

This Voltage correction is optional. User can Disable / Enable this Voltage correction by V-CORRECTION parameter in MMI. Other parameter related to the Voltage correction is the V-CONTROL i.e. Voltage Controlling strategy.

There are two Controlling strategies offered by SR-1. One is Proportional Control (PC) and the other is Adaptive Control (AC). In Proportional Control(P) strategy the correction signal is sent in terms of PWM to Relay/ Current/ or voltage section. The Time period of the pulse is constant but the Pulse width of ON time of PWM is decided according to following method :

Correction Pulse on Time = Kpv * Error

Where Error. = [(Measured ΔU) – (set ΔU)].

Kpv is decided by user through MMI.

Unit of the Proportional Gain factor is s/V.

Take the example of following setting:

V-CORRECTN = ON

V-CONTROL = PC

AVRTWmax = 1.3s

Kpv = 0.1s/V

This means that on the error of 1volt, SR1 will generate a correction pulse with on period of 0.1sec & off period of 1.2 sec (1.3 - 0.1). The next correction pulse will be sent only after 1.2sec. Correction pulses will be sent in proportion to Error and proportional gain (Kpv) set by the user in MMI.

In case of adaptive control strategy (AC), SR1 will generate the correction pulse according to the response of the AVR. It will dynamically check the response and according to the error will decide the ON period of the correction pulse. For this to become active, the user has to set the parameter V-CONTROL = AC.

5.1 Operation of voltage control output relays

When one of the operating conditions is met (to either increase or decrease the voltage) the pulse cycle of the appropriate output relay is started.

- The cycle is repeated in every time period of [AVRTWmax] setting.
- The relay remains energized (pulse duration) not less than the time [AVRTWmin>=] and not longer than the time [<=AVRTWmax].
- The actual pulse duration ON is proportional to the error according to the set value of the gain [Kpv in s/V].

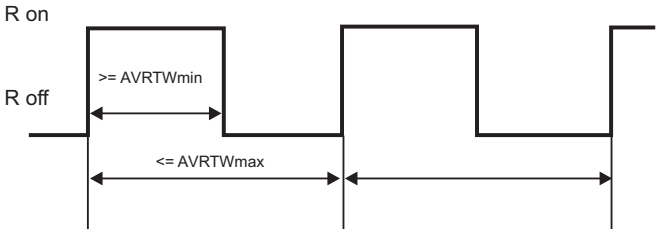


Fig. 7 : Speed control characteristic

6 Speed regulator operation

The frequency regulator control of the SR1 operates when the frequency of the generator is below that of the bus frequency or above the set operational tolerance given by $F_G > [F_B + \Delta F]$

Where:

F_G = frequency of the generator

F_B = frequency of the bus

ΔF = the frequency regulation bandwidth

Note : that this ensures that the circuit breaker is permitted to close only when the generator frequency is at or above the bus frequency thereby avoiding a motoring condition.

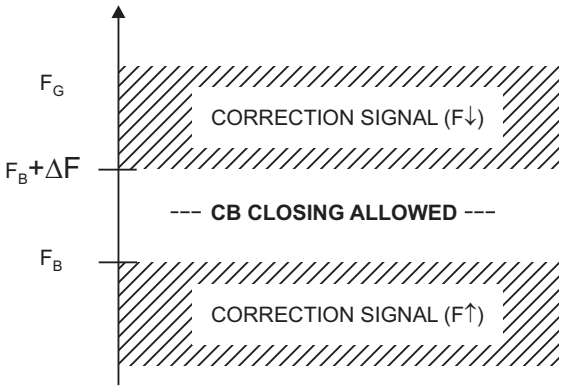


Fig. 8: Speed (Frequency) Regulator Operating Characteristic

The frequency correction is optional. User can Disable / Enable frequency correction by F-CORRECTION parameter in MMI. Other parameter related to the frequency correction is the F-CONTROL i.e. frequency controlling strategy. There are two Controlling strategies offered by SR1. One is Proportional Control (PC) other is Adaptive Control (AC). In Proportional Control (P) strategy the correction signal is sent in terms of PWM to Relay / Current / voltage section. The Time period of the pulse is constant but the ON time of PWM is decided according to following principle :

Correction Pulse ON Time = Kpv * Error

Where Error. = [(Measured ΔF) – (set ΔF)].

Kpf is decided by user through MMI.

Unit of the proportional gain factor is s/Hz.

Take the example of following setting:

F-CORRECTN = ON

F-CONTROL= PC

GOVTWmax = 1.3s

Kpf= 0.1s/Hz

This means that when the Error is 1Hz, SR1 will generate a correction pulse with on period of 0.1sec and Time period of 1.3sec. In this case the next correction pulse will be sent only after 1.2sec. In this way correction pulse will be sent in proportion to error and proportional gain (Kpf) set by the user in MMI.

In case of adaptive control strategy (AC), SR1 will generate the correction pulse according to the response of the AVR. It will dynamically check the response and according to the error will decide the ON period of the correction pulse. This is achieved if the parameter V-CONTROL = AC.

6.1 Operation of speed control output relays

When one of the operating conditions is met (to either increase or decrease the speed) the pulse cycle of the appropriate output relay is started.

- The cycle is repeated every period [GOVTWmax]
- The relay remains energized (pulse duration) not less than the time [GOVTWmin>=] and not longer than the time [<=GOVTWmax]
- The actual pulse duration (ON period) is proportional to the measured frequency difference according to the set value of the gain [s/Hz]

See Figure 9.

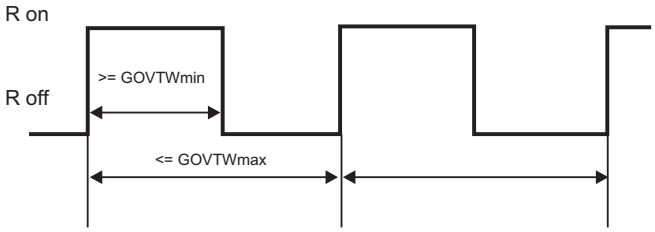


Figure 9: Voltage Regulator Output Contacts Pulse Characteristics

6.1.2 Kicker pulse control

When the slip frequency is zero or very close to zero and the phase displacement between the generator and bus voltages are not within the setting limits, it may not be possible to achieve synchronism in a reasonable period of time. When such a condition is detected, the SR1 generates a so-called "kicker pulse", that is, an "increase speed" pulse is generated even though the frequency is within the set limits. This causes the generator to accelerate, increasing the slip frequency, and permitting all closing conditions, including an appropriate displacement angle, to be met. Kicker pulse is generated when the frequency difference goes below 0.02Hz.

7 Relay Testing and Commissioning

One of the most important items to check during the commissioning of generators which will operate in parallel is that connection of cables associated with synchronizing equipment is correct. If voltage transformer connection is incorrect, malsynchronization can occur, with the risk of considerable damage since even though synchronizing equipment may give the correct indication it is possible that the two systems to be synchronized are out of phase.

The usual method of ensuring that synchronizing connections are correct is as follows:

1) Remove the generator connections at the suitable location such that the generator circuit voltage transformer can be safely energized
2) Put the relay in Test Mode

   The synchroscope of SR1 should indicate zero phase displacement and the centre green LED should light. This indicates that the two systems are within +/- 9 degrees.

If, however, the any red LED glows instead of the green one, the following can be concluded:

- Reading 141-180 degrees: changeover connections Of generator voltage.
- Reading 101-140 degrees: Generator and bus bar voltages are derived from different phases.
- Reading 41-67 degrees: Generator and bus bar voltages are derived from different phases.

In order to check the correct functioning of the synchronizing unit, frequency and voltage control facilities, put the SR-1 in test mode. With the generator running check if the automatic voltage control functions are operating correctly: With the generator running, temporarily connect the appropriate wires to governor control terminals 9 thru 12. Observe the difference between busbar and generator frequency LED's "Faster" and "Slower". If the frequency difference is reducing, this indicates correct functioning of the frequency control device. If the frequency difference is increasing, the connection on governor control (9 thru 12) must be reversed. This test should then be repeated to check the voltage control unit. In this case, however, the relevant terminals are 13 thru 16 and LED' "Increase" and "Decrease" should be observed

8 Setting Procedure

8.1 Menu Frames

Menu 1 Default Page (Running Parameters)	MODE: splays selected mode> Vb XXX.X V Fb XX.XX Hz Vg XXX.X V Fg XX.XX Hz STATUS: <Present status of SR1>
Menu 2 (Pressing Enter Key)	MODE SELECTION EDIT/VIEW PARAMETERS HOOTER ASSIGNMENTLOAD DEFAULTS CHANGE PASSWORD BACK TO PREV PAGE
Menu 3 (Pressing Enter Key on MODE SELECTION)	# MODE SELECTION # AUTO MODE MANUAL MODE TEST MODE BACK TO PREV PAGE
Menu 4 (Pressing Enter Key on MANUAL MODE)	#MANUAL CORRECTION# AVR CORRECTION GOV CORRECTION BACK TO DEFAULT PAGE
Menu 5 (Pressing Enter Key on AVR / GOV Correction Mode)	MODE: MANUAL Vb XXX.X V Fb XX.XX Hz Vg XXX.X V Fg XX.XX Hz BACK TO PREV PAGE
Menu 6 (Pressing Enter Key on Edit/ View Mode)	# EDIT PARAMETERS # SLIP FREQ VOLTAGE DIFF PHASE DIFF CB DELAY SYNCH ATTEMPTS SYNCH TIMEOUT DEADBUS STATUS V-CORRECTN F-CORRECTN V-CONTROL F-CONTROL Kpv Kpf AVRTWmax GOVTWmax AVRTWmin GOVTWmin Vgmax Vgmin Fgmax Fgmin Vbmax Vbmin Fbmax Fbmin BACK TO PREV PAGE
Menu 7 (Pressing Enter Key on HOOTER ASSIGNMENT)	# HOOTER ASSIGNMENT# [ ] AVR FAULT [ ]GOV FAULT [ ]GEN UNHEALTHY [ ]BUS UNHEALTHY [ ]SYNC FAILURE [ ]CB/SLIP FAULT BACK TO PREV PAGE
Menu 8 (Pressing Enter Key on LOAD DEFAULT)	Enter Password Loading . . .
Menu 9 (Pressing Enter Key on CHANGE PASSWORD)	Enter PASSWORD Enter new PASSWORD Re-Enter PASSWORD SUCCESS : PASSWORD CHANGED!
Menu 10	Save modification? YES NO CANCEL
Menu 11	Enter PASSWORD SAVING …
Menu 12	Enter Password! INVALID PASSWORD!

8.1.1 Basic Key Functions

KEY	FUNCTION
RESET	Reset annunciation / relay
➤	Previous item / menu
+	Increment selected quantity / check the box
-	Decrement selected quantity / check the box
➤	Next item / menu
ENTER	Confirm selection of item in the menu / save value

- All keys can be used in selecting/specifying password
- Pressing Reset key for 3 sec, cursor will go back to the previous page.

8.1.2 'How to' Guide

How to	KEY TO BE PRESSED	MENU DISPL-AYED
View Running parameters	Do not touch any key for 1 minutes; running parameters will appear on the screen after applying the auxiliary supply to SR1.	Menu 1
Edit Parameters of desired function	If you are in menu 1 then Press ENTER key and using →&← keys bring cursor/blinking on EDIT/ VIEW PARAMETERS option. Select this menu by pressing ENTER key. Scrollthrough different functions using →&←keys. By using INC & DEC keys parameters value can be increased or decreased. By pressing ENTER key SR1 will ask whether to save the edited parameter .Press → or ← key to move to YES, NO or CANCEL. If YES is selected by pressing ENTER SR1 will ask for password. Enter the password and the parameter will be saved.	Menu 2 Menu 5 Menu 9 Menu 10,11
Hooter Relay Assignment	Select the option HOOTER ASSIGNMENT from Menu 2 by pressing ENTER key, display shows [ ] AVR FAULT [ ] GOV FAULT ….. which means Hooter relay is not assigned to the corresponding parameter. In order to assign Hooter relay press INC/DEC key display shows [*] AVR FAULT The assignment can be saved by pressing ENTER and subsequent input of the password.	Menu 6 Menu 9-11
Select Auto/ Manual/ Test Mode	Select the MODE SELECTION from menu 2, by pressing ENTER. SR1 will display Menu 3. Scroll and select one of the mode by pressing ENTER key. In selection of AUTO and TEST mode, SR1 will come back to Default screen i.e. Menu 1. In case of Manual mode, Menu 4 will appear. Selection of AVR correction or GOV correction will display the Menu 5. Using INC/ DEC keys in manual mode will send the correction signal to AVR or GOV.	Menu 2 Menu 3 Menu 4

9 Technical Data

Editable Parameters

Description	Displayed As	Range	Steps Size	Default Setting
Frequency Difference between Bus bar and Generator in percentage of Nominal Freq	SLIP FREQ	0.02% - 3% of F_N	0.01%	1.00%
Voltage Difference between Bus bar and Generator in percentage of Nominal voltage	VOLTAGE DIFF	0.4% — 10% of V_N	0.1%	5.0%
Phase difference between Bus bar and Generator	PHASE DIFF	3° –20°	1 °	3 °
Generator CB on Delay	CB DELAY	10 – 400 msec	1 msec	30 msec
No of synchronizing attempts	SYNCH ATTEMPTS	1—10	1	2
Interval over which relay will attempt to get synchronization, after getting the command of Sync Start	SYNCH TIMEOUT	1min – 10min	1min	2min
Dead bus Enable/Disable	DEADBUS STATUS	ON/OFF	x	OFF
Required Bus Voltage	V-NL	100% to 115% of VN	0.1% with 2% hysterisis	100%
Required Bus Frequency	F-NL	100% to 105% of FN	0.1% with 0.2% hysterisis	103%
Voltage Correction	V-CORRECTN	ON/OFF	x	OFF
Frequency Correction	F-CORRECTN	ON/OFF	x	OFF
Voltage Control Process (Proportional /Adaptive Control)	V-CONTROL	PC / AC	x	PC
Frequency Control Process (Proportional /Adaptive Control)	F-CONTROL	PC/ AC	x	PC
Proportional Gain which determines how fast the SR1 responds to an error in voltage	Kpv	0.01 – 2 s /V	0.01 s/V	0.05 s/V

Proportional Gain which determines how fast the SR1 responds to an error in frequency	Kpf	0.01 – 2 s /Hz	0.01 s/Hz	0.05 s/Hz
Maximum Time period of correction pulse to AVR for voltage correction	AVRTWmax	1.0 – 5.0 sec	0.1 sec	1.3 sec
Maximum Time period of correction pulse to GOVERNOR for frequency correction	GOVTWmax	1.0 – 5.0 sec	0.1 sec	1.3 sec
Minimum ON period of correction pulse to AVR for voltage correction	AVRTWmin	0.1—2sec	0.1 Sec.	0.3 Sec
Minimum ON period of correction pulse to GOVERNOR for frequency correction	GOVTWmin	0.1—2sec	0.1 Sec.	0.3 Sec
Maximum Generator Voltage for considering the Generator healthy	Vgmax	50-500V	1 V	500V
Minimum Generator Voltage for considering the Generator healthy	Vgmin	50-500V	1 V	50V
Maximum Generator Frequency for considering the Generator healthy	Fgmax	40-70 Hz	1Hz	55 Hz
Minimum Generator Frequency for considering the Generator healthy	Fgmin	40-70 Hz	1Hz	45 Hz
Maximum Bus bar Voltage for considering the Generator healthy	Vbmax	50-500V	1 V	500V
Minimum Bus bar Voltage for considering the Generator healthy	Vbmin	50-500V	1 V	50V
Maximum Bus bar Frequency for considering the Generator healthy	Fbmax	40-70 Hz	1Hz	55 Hz
Minimum Bus bar Frequency for considering the Generator healthy	Fbmin	40-70 Hz	1Hz	45 Hz

Table 3: Different parameter settings in Edit mode

Note :

1) Don't change the parameters while synchronization is going on. It is preferable to change the parameters in TEST mode or when relay is idle (In absence of Synch Start DI).

2) The Default Password for SR1 is "ENTER-ENTER-ENTER-ENTER".

10 Functional Specifications

S.No	Parameter	Specification	
1	Mode	Auto	In Auto mode frequency control, voltage control and CB control functions are all automatic.
2		Manual	Manual mode allows the user to manually adjust frequency and voltage. When the Voltages & Frequencies are within band, issues CB closing command.
3		Test	Similar to auto mode except No CB closing command. Test mode allows user to verify the controlling action of SR1.
4	Display Function	Default Display	Generator & Bus bar Voltage XXX.XV (RMS value.) Generator & Bus bar Frequency XX.X Hz Relay Status : <Present processing of relay>
5		View / Edit Parameters	View / Set all parameters described in the table of Section 9. SET function is protected by Password.
6		Change Password	Password can be modified. Protected by password. (The Default Password for SR1 is 4-times Enter Key)
7		Load Default	Loads default parameters (described in the table of Section 9) including password and resets diagnostics parameters.

11 Performance Specifications

S.No	Parameter	Specification
1	Aux Supply	20V DC to 360 V DC and 25V AC to 270V AC.
2	Aux supply burden	< 6VA
3	Nominal Voltage :	110V / 80-150V 230V / 180-260V 400V / 340-460V
4	Tolerance in Voltage Measurement	±1%
5	Tolerance in Frequency Measurement	±0.5%
6	Rated frequency	50 Hz
7	Tolerance in phase difference measurement	±1°

12 Hardware Specifications

S.No	Parameter	Specification
1	Display	20 characters/row x 4 rows LCD display with built in controller
2	Annunciation using LEDs(23 numbers)	Synchroscope(13 LEDs), <U>, <f>, CB , SYNC OVER, AVR↑ AVR↓, GOV↑, GOV↓ , Communication, Fault
3	Key Pad 6 Keys	Select, Increment, Decrement, Enter, Cancel, Reset
4	Controls: Opto-isolated I/Ps – 2:	Start Sync, Dead Bus Enable
5	Relays	250VAC 10A / 24V DC 3-Relays in all models:-CB, Sync Over, Hooter (and optionally :-AVR↑ , AVR ↓, GOV↑, GOV↓)
6	Current Loop O/P (Optional)	4-20mA (Max load resistance : 300R) Max. and min. input current : ± 5% for 4-20 mA,
7	Voltage O/P (Optional)	In analog voltage o/p options, there are four options: [-1 -0- +1]V or [-3-0- +3]V or [-9 -0 -+9]V, [0-5]V Tolerance : ± 5% Min load resistance: 1kΩ These options are available on specific demand.
8	Storage temp.	- 40^0C - +75^0C
9	Operating Temp	- 20^0C - +70^0C
10	Connecting terminals	max 2.5 mm^2 Recommended 2.5 mm^2 conductor
11	Enclosure	1. Flush mounting 2. Panel Cut-Out: (W x H) 178 x 140 mm 3. Dimensions: (W x H x D) 214 x 140 x 80 mm 4. Weight: 1.2 Kg appx.

13 Terminal Details

13.1 Terminal arrangement

The terminal arrangement of the SR1 is shown in Figure 10 :

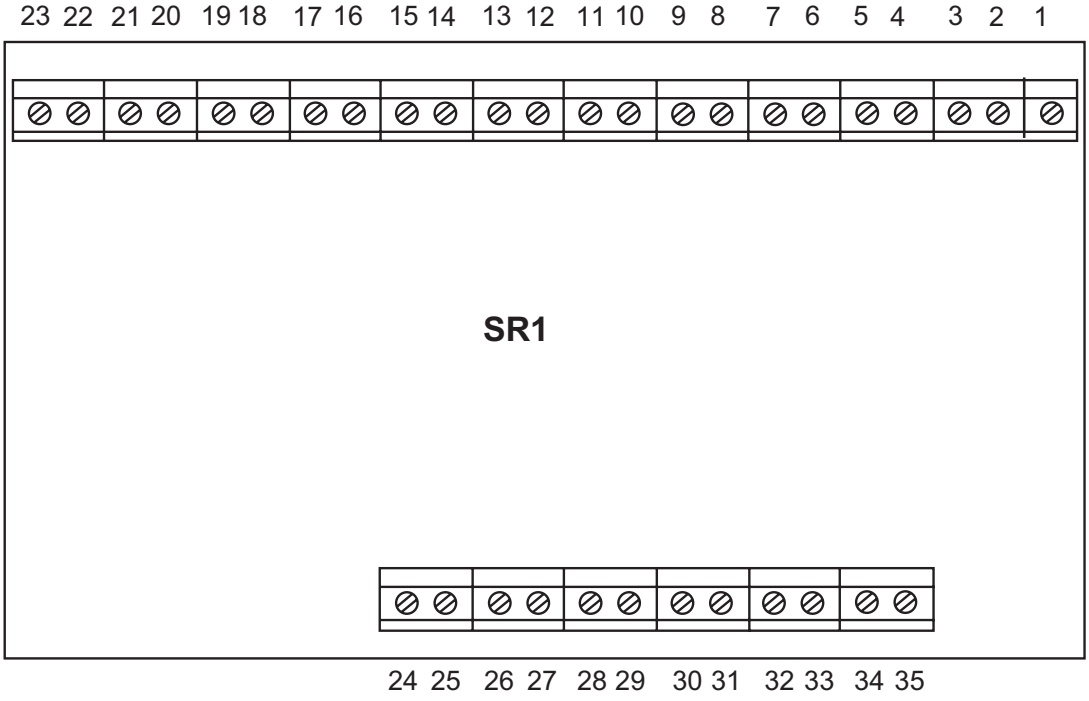


Fig. 10

13.1.1 Terminal description ['X' stands for 'No Connection']

Terminal No	Description According to Model		
	SR1-R x	SR1-C x	SR1-V x
1,2	Bus bar Voltage	Bus bar Voltage	Bus bar Voltage
3,4	Generator Voltage	Generator Voltage	Generator Voltage
5,6	X	X	X
7,8	Hooter/Alarm	Hooter/ Alarm	Hooter/ Alarm
9,10	Governor ⇧	X	X
11,12	Governor ⇩	4-20mA, GND	(+/-1,+/-3,+/-9 V,0-5V), GND
13,14	AVR ⇧	X	X
15,16	AVR ⇩	4-20mA, GND	+/-1, +/-3, +/-9 V, 0-5V, GND
17,18	Synch Over	Synch Over	Synch Over
19,20	Generator CB	Generator CB	Generator CB
21,22	Auxiliary supply	Auxiliary supply	Auxiliary supply
23	Earth	Earth	Earth
24	X	X	X
25	X	X	X
26	X	X	X
27	X	X	X
29	Synch Start	Synch Start	Synch Start
30	Dead Bus Enable	Dead Bus Enable	Dead Bus Enable
31	Common for 29/30	Common for 29/30	Common for 29/30
34	X	X	X

13.1.2 Connection Diagram

Electrical Connection of SR-1R x Relay

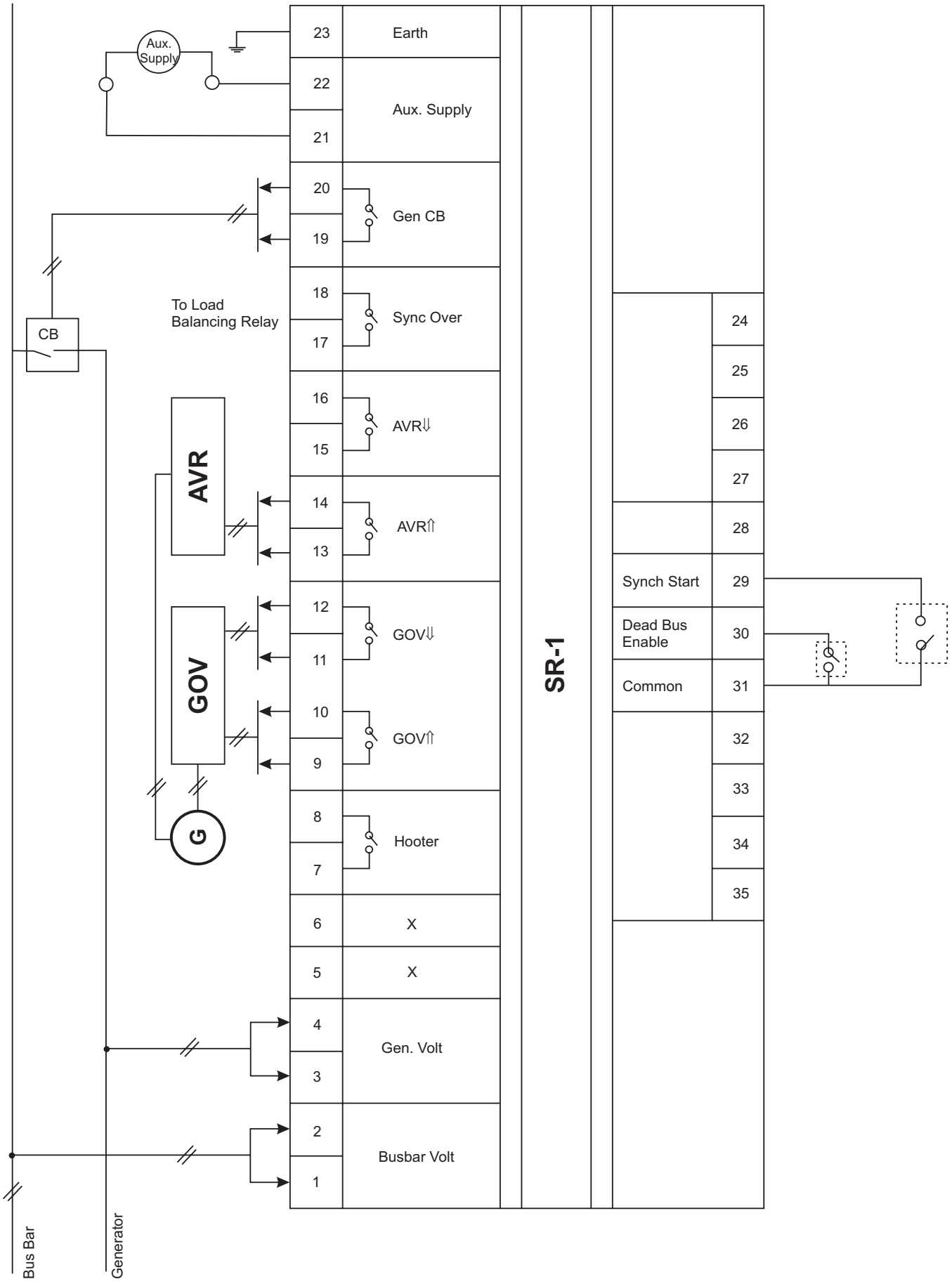
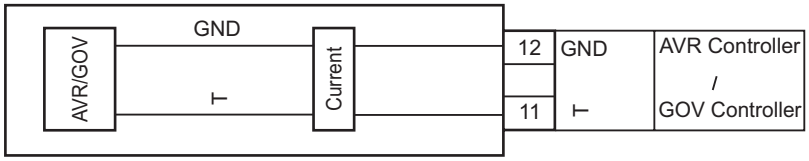
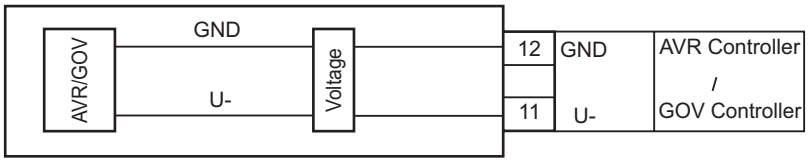


Fig. 11

In SR-C x Model, all electrical connections are same as in SR1-R except AVR/GOV connections, as per shown figures



In SR1V x Model, all electrical connections are same as in SR1-R except AVR/GOV connections, as per shown figures



13.1.3 Block Diagram

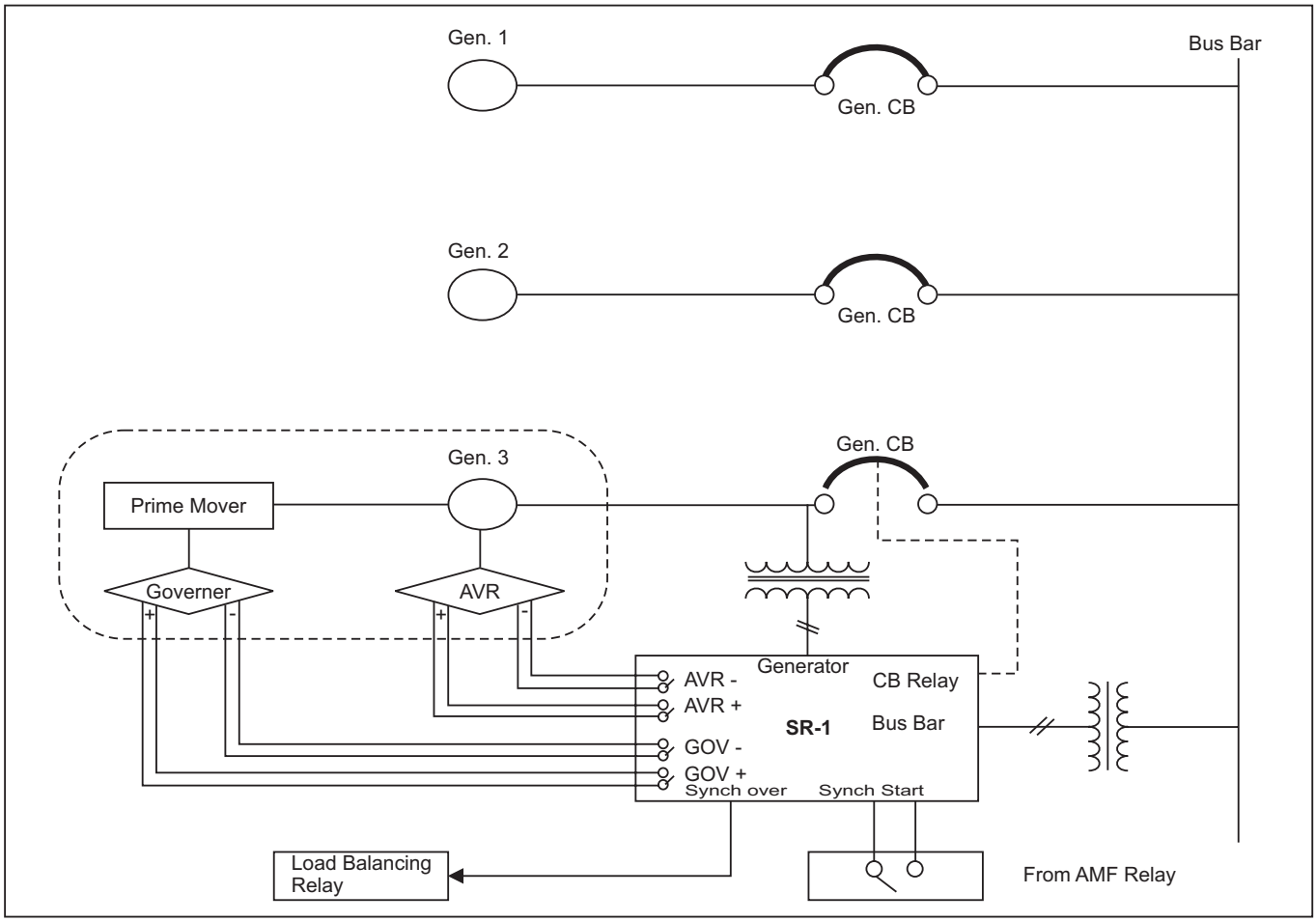


Fig. 12

13.1.4 Dimensions

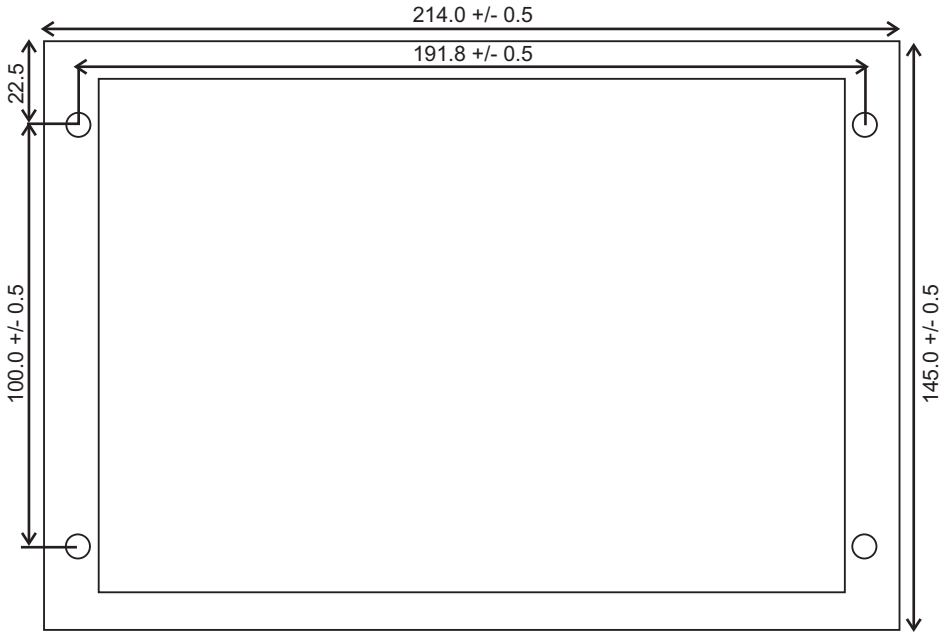


Fig. 13 : Panel Cut-out : 182 x 144 Installation Depth : 80 All dimensions in mm

14 Order Form

Synchronizing relay	**SR1**			
AVR Control Relay		**R**		
	- ±1 Voltage	**V1**		
	- ±3 Voltage	**V3**		
	- ±9 Voltage	**V9**		
	- 0-5 Voltage	**V5**		
	- Current (4-20mA)	**C**		
GOV Control Relay			**R**	
	±1 Voltage		**V1**	
	- ±3 Voltage		**V3**	
	- ±9 Voltage		**V9**	
	- 0-5 Voltage		**V5**	
	- Current (4-20mA)		**C**	
Measuring Voltage AC (V_N) -				**110V**
				230V
				400V

Range of Protection Relays

BASIC RANGE

- Micro-controller based compact economical design
- DIN rail mounted
- Status indication via LED
- Step-less settings through front potentiometer

FUNCTIONAL RANGE

- Genset Supervision & Control
- Auto Synchroniser
- Load Balancing & Control
- Related Protection

HIGH-TECH RANGE

- Microprocessor based numerical protection
- Event & fault recording
- RS 485 communication
- Bright alpha-numeric display

INTEGERATED RANGE

- Numeric protection, solution for sub-station in association with INGETEAM T&D, Spain
- Distance protection
- Comprehensive transformer protection –

  a. Three winding transformer
  b. Two winding transformer
- Multi-functional relay: variety of protection combination

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