SmartGen
MAKING CONTROL SMARTER

HVR620

DIGITAL VOLTAGE REGULATOR

USER MANUAL

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Table 1 Software Version

Date	Version	Note
2025-01-03	1.0	Original Release
2025-05-14	1.1	1. Add the HVR410 model for model comparison; 2. Modify some descriptions in the performance features and technical parameter; 3. Change the minimum remanence voltage to 8VAC; 4. Modify the logic in the lower voltage protection; 5. Modify some descriptions in the U/F slope characteristic; 6. Modify the description in the real-time data analysis; 7. Modify the description of the CAN communication baud rate in the technical parameter; 8. Modify the description of the CAN communication indicator; 9. Add the excitation PID parameter configuration item in the parameter setting; 10. Add the J1939-75 transmission enable and AVR fine-tuning parameter configuration items in the parameter setting; 11. Modify the CAN communication protocol; 12. Modify the front indication diagram.

Table 2 Symbol Instruction

Symbol	Instruction
NOTE	Highlights an essential element of a procedure to ensure correctness.
CAUTION	Indicates a procedure or practice, which, if not strictly observed, could result in damage or destruction of equipment.
WARNING	Indicates a procedure or practice, which could result in injury to personnel or loss of life if not followed correctly.

CONTENTS

1 OVERVIEW

HVR620 Digital Voltage Regulator is used to adjust the field current of brushless AC synchronous generator, which can be applied to generators with the excitation system of PMG, AUXW or SHUNT. The excitation regulation mode of the regulator is automatic voltage regulation (AVR). It has USB interface and CAN BUS interface.

The product adopts 32-bit micro-processor technology, which can achieve precision measurement of multiple parameters, protection threshold adjustment, real-time data monitoring and analysis, flexible and comprehensive fault protection, etc. All parameters can be read and configured on PC via USB interface. And it features compact structure, simple connections and high reliability.

2 MODEL COMPARISON

Table 3 Model Comparison

Items		**HVR620**	HVR1000	HVR410
Regulation Mode	AVR Mode	●	●	●
	FCR Mode		●	
	VAR Mode		●	
	PF Mode		●	
Generator Voltage Detection		●	●	●
Generator Current Detection			●	●
Excitation Power Supply		63VDC Excitation System: (100-139)VAC or 125VDC 125VDC Excitation System: (190-277)VAC or 250VDC	63VDC Excitation System: (100-139)VAC or 125VDC 125VDC Excitation System: (190-277)VAC Single Phase, (190-260)VAC Three Phase or 250VDC	AC(100-264)V
Field Current		4A 7.5A@10s (short-time)	7A 14A@10s (short-time)	4A 7.5A@10s (short-time)
Analog Inputs	Voltage		●	●
	Resistance		●	●
Number of Inputs			4	
Number of Outputs			2	
Rated Voltage Potentiometer		●		●
Communication Interface	Bluetooth		●	
	CAN	●	●	
	USB	●	●	●
Temperature Protection	Winding	●		
	Heat Sink	●		●
Real-time Clock			●	
Event Log		●	●	●

Items	**HVR620**	HVR1000	HVR410
Running Data Log		●	
Alarm Data Log (Black Box)	●	●	●

NOTE: The functions of HVR1000 and HVR410 mentioned in this document may be changed. For accurate information, please refer to the corresponding HVR1000 or HVR410 user manual.

3 PERFORMANCE FEATURES

Main features are as following:

- Excitation regulation mode: automatic voltage regulation (AVR);
- Over-excitation limit, U/F limit function is fitted;
- Soft start function is fitted;
- PID algorithm for excitation regulation;
- Three ways to adjust voltage: potentiometer, parameters configuration on PC, CAN communication;
- Excitation power supply: voltage input is (100-277) VAC (1P2W) or DC voltage;
- Continuous field current is 4A, maximum short-time current is 7.5A for 10s;
- With load compensation function (LCF);
- Suitable for AC systems of 3P3W, 3P4W, 2P3W and 1P2W at rate frequency between 10Hz and 200Hz;
- Detect generator voltage harmonic THDu, and 1st-15th odd harmonic;
- The measured generator voltage represents a true RMS value;
- Collect excitation voltage, field current, generator voltage, frequency, etc.;
- Function of heat sink temperature detection and alarm protection;
- Function of winding temperature detection and alarm protection;
- Protection and detection function: gen. over/under voltage, gen. over/under frequency, gen. unbalanced voltage, gen. harmonic distortion, gen. unavailable, excitation over voltage, excitation overcurrent, rotating diode fault, etc.;
- Real-time data curve analysis can be done to adjust PID parameters via PC software;
- All parameters can be configured on PC via USB interface;
- Data monitoring can be realized via the CAN communication interface;
- It can be applied to all types of brushless AC synchronous generators with the excitation system of PMG, AUXW, or SHUNT;
- Event log function can cyclically record 999 events based on the running time;
- Black box function enables it to record 5 groups of fault alarm data cyclically;
- Modular design, pluggable terminal, screw fixing, compact structure and easy installation.

4 SPECIFICATION

Table 4 Technical Parameters

Items	Contents
Excitation Power	63VDC system: (100-139) VAC or 125VDC; 125VDC system: (190-277) VAC or 250VDC; Frequency: (50-500) Hz or DC.
Excitation Output Current	Continuous current: 70VDC, 4A; Maximum short-time current: 10s, 70VDC, 7.5A; Coil resistance>4Ω.
AC Voltage Regulation	Accuracy: 0.25%, THDu < 5%.
AC Sampling Voltage	Line voltage Range: 30VAC - 720VAC (ph-ph) Resolution: 0.1V Accuracy: 0.2%
	AC frequency Range: 10Hz - 200Hz Resolution: 0.01Hz Accuracy: 0.1Hz
Rotary DIP Switch	One 10-position rotary DIP switch (To set the number of winding temperature sensors connected)
Analog Input	One way PT100 (Two wire type) Range: (-50~+150)°C Resolution: 0.1°C Accuracy: 1°C
Potentiometer	One for rated voltage regulation
CAN Interface	Isolated, using Belden 9841 cable or equivalent cable Please refer to Table 9 for transmission and communication baud rate.
USB	Isolated Type-C interface
Vibration	(18-2000)Hz: 5g (Refer to IEC 60068-2-6)
Shock	$50g_n$, 11ms, half-sine, apply three shocks successively in each direction of three mutually perpendicular axes, which means 18 shocks in total. Refer to IEC 60068-2-27.
Bump	20g, 16ms, half-sine (Refer to IEC 60255-21-2)
Overall Dimension	153mm x 138mm x 61mm
Working Temperature	(-40~+70)°C
Working Humidity	(20~95)%RH
Storage Temperature	(-40~+85)°C
Weight	0.7kg
Installation	Fixed by screws
IP Rating	IP20

5 OPERATION

5.1 ILLUSTRATION

5.1.1 INDICATORS AND WIRING

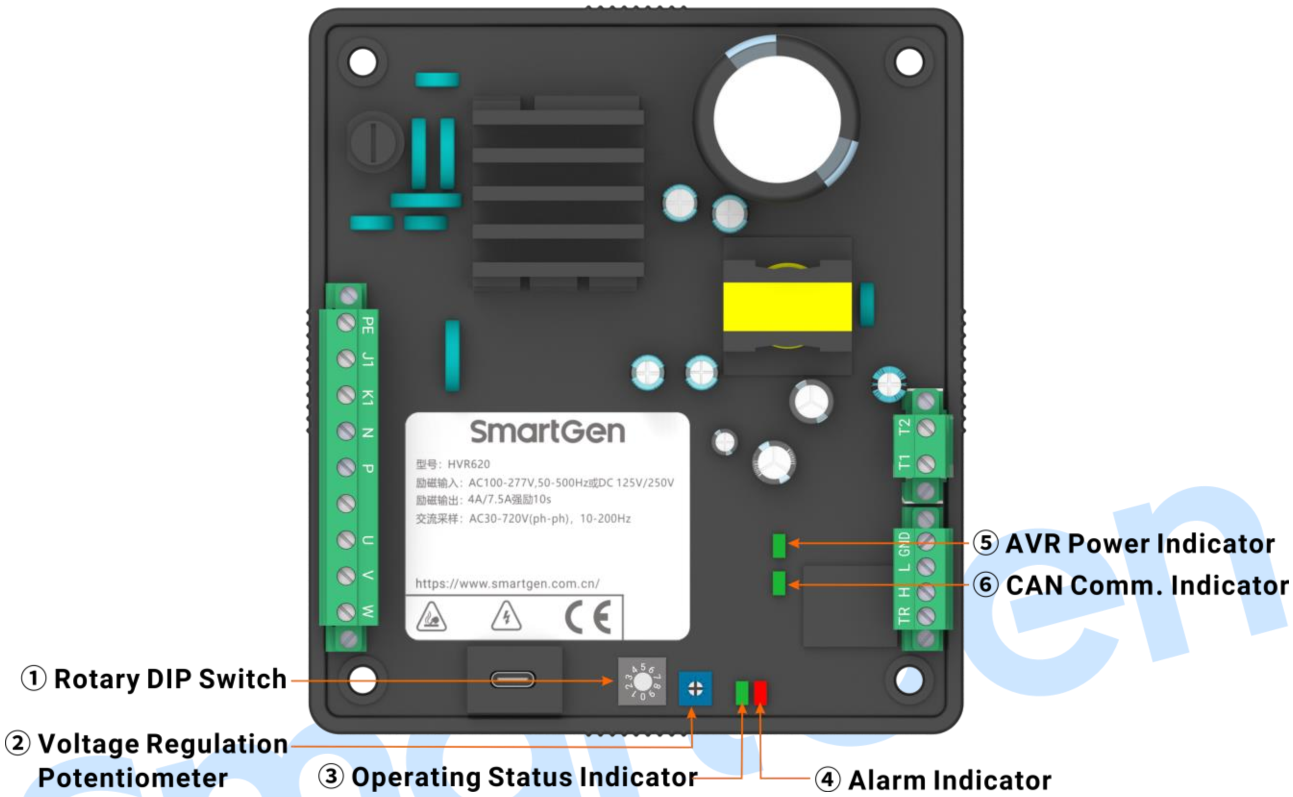


Fig. 1 Front Indication Diagram

Table 5 Rotary DIP Switch Position Description

No.	Position	Function
1	0	Three PT100 winding temperature sensors
	1	Two PT100 winding temperature sensors
	2-9	Reserved

Table 6 Voltage Regulation Potentiometer Description

No.	Rotation Direction	Function
2	Counterclockwise	To reduce generator voltage output
	Clockwise	To increase generator voltage output

Table 7 Indicators Description

No.	Type	Function	Description
3	Operating Status Indicator (green)	Status	When AVR excitation output is normal or warning alarm occurs (which doesn't influence the excitation output), it will be always on, and it will be off when AVR fault alarm occurs.

No.	Type	Function	Description
4	Alarm Indicator (red)	Alarm	When no AVR alarm occurs, it is off; When AVR fault alarm occurs, it is always on; When AVR warning alarm occurs, it flashes once/s.
5	AVR Power Supply Indicator (green)	Status	It is always on after AVR is powered on.
6	CAN Communication Indicator (green)	Status	When CAN communication is off, it is off; When CAN communication is normal, it is always on.

Table 8 Terminal Wiring Description

No.	Function	Size	Remarks
PE	Protective Ground	1.5mm^2	Grounding wire of the power supply system.
J1	Positive Pole	1.5mm^2	Excitation output.
K1	Negative Pole	1.5mm^2	
N	Power Input	1.5mm^2	Excitation power input.
P		1.5mm^2	
Null	Auxiliary Power Input	1.5mm^2	It is connected to the Terminal U internally. For SHUNT generator, short this terminal with Terminal P directly to provide excitation power input. For AUXW generator, it is unused terminal.
U	Generator U-phase Monitoring Input	1.5mm^2	It is connected to generator output U phase.
V	Generator V-phase Monitoring Input	1.5mm^2	It is connected to generator output V phase.
W	Generator W-phase Monitoring Input	1.5mm^2	It is connected to generator output W phase.
DEVICE	USB	Isolated	Type-C interface. The module can be powered via the interface. And parameters read/write configuration to the voltage regulator, real-time data monitoring and program upgrade can be done on PC software via the interface.
TR	CAN TR	0.5mm^2	120Ω impedance shielded cable is recommended. Short Terminal CAN TR with Terminal CAN H directly to connect the 120Ω termination resistor.
H	CAN H	0.5mm^2	
L	CAN L	0.5mm^2	
GND	CAN Ground	0.5mm^2	
T1	Winding Temp. Sensor Input	1.0mm^2	Winding temperature sensor wiring input terminal.
T2		1.0mm^2	

⚠**NOTE:** USB interface of the voltage regulator can directly connect PC to do parameter configuration in standby and running status.

⚠**NOTE:** Do not upgrade the program while the generator is running.

5.1.2 EXCITATION OUTPUT

Excitation output provides DC excitation power input for exciter. Excitation output terminals are J1 and K1.

It can provide continuous working current of 4A, and in forced excitation mode, the maximum field current is 7.5A for 10s.

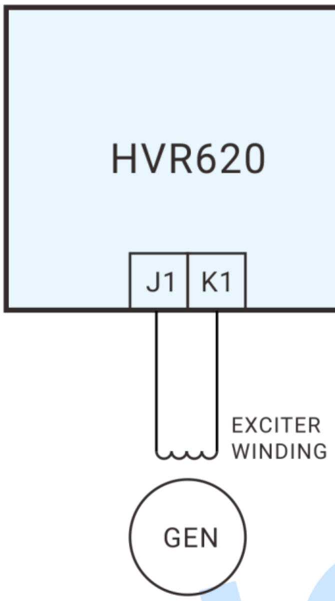


Fig.2 Excitation Output Wiring Diagram

5.1.3 EXCITATION POWER INPUT AND GENERATOR VOLTAGE DETECTION INPUT

Excitation power input (P&N) will provide power for excitation control output, and working power for voltage regulator.

The recommended minimum remanence voltage is 8VAC at 25Hz.

Voltage detection terminals of 3-phase generator are U, V, W.

The AC input range of detection terminals is 30VAC - 720VAC (ph- ph).

The generator voltage is the average value of 3-phase line voltages. When the generator voltage is unbalanced, the generator voltage is the maximum line voltage.

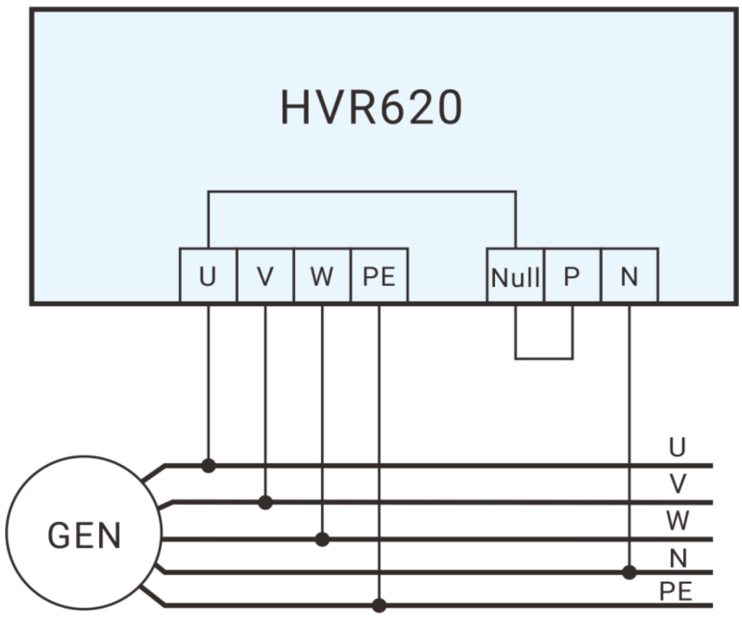


Fig.3 Generator Voltage Detection and Excitation Power Input (SHUNT) Wiring Diagram

5.1.4 CAN COMMUNICATION INTERFACE

There is one CAN communication interface.

The 120Ω impedance shielded cable is recommended. Short Terminal TR with Terminal H directly to connect the 120Ω termination resistor.

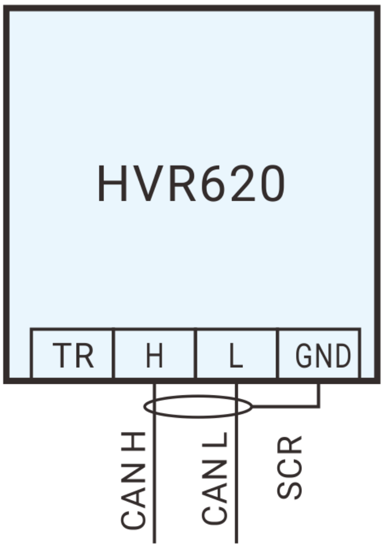


Fig.4 Wiring Diagram of CAN Communication

Table 9 Relation Between CAN-bus Transmission Distance and Baud Rate

No.	Comm. Distance (m)	Max. Baud Rate (bps)
1	700	50k (Termination resistor is 120Ω)
2	280	125k (Termination resistor is 120Ω)
3	140	250k (Termination resistor is 120Ω)
4	70	500k (Termination resistor is 120Ω)

5.2 EXCITATION REGULATION INSTRUCTION

5.2.1 SCHEMATIC DIAGRAM

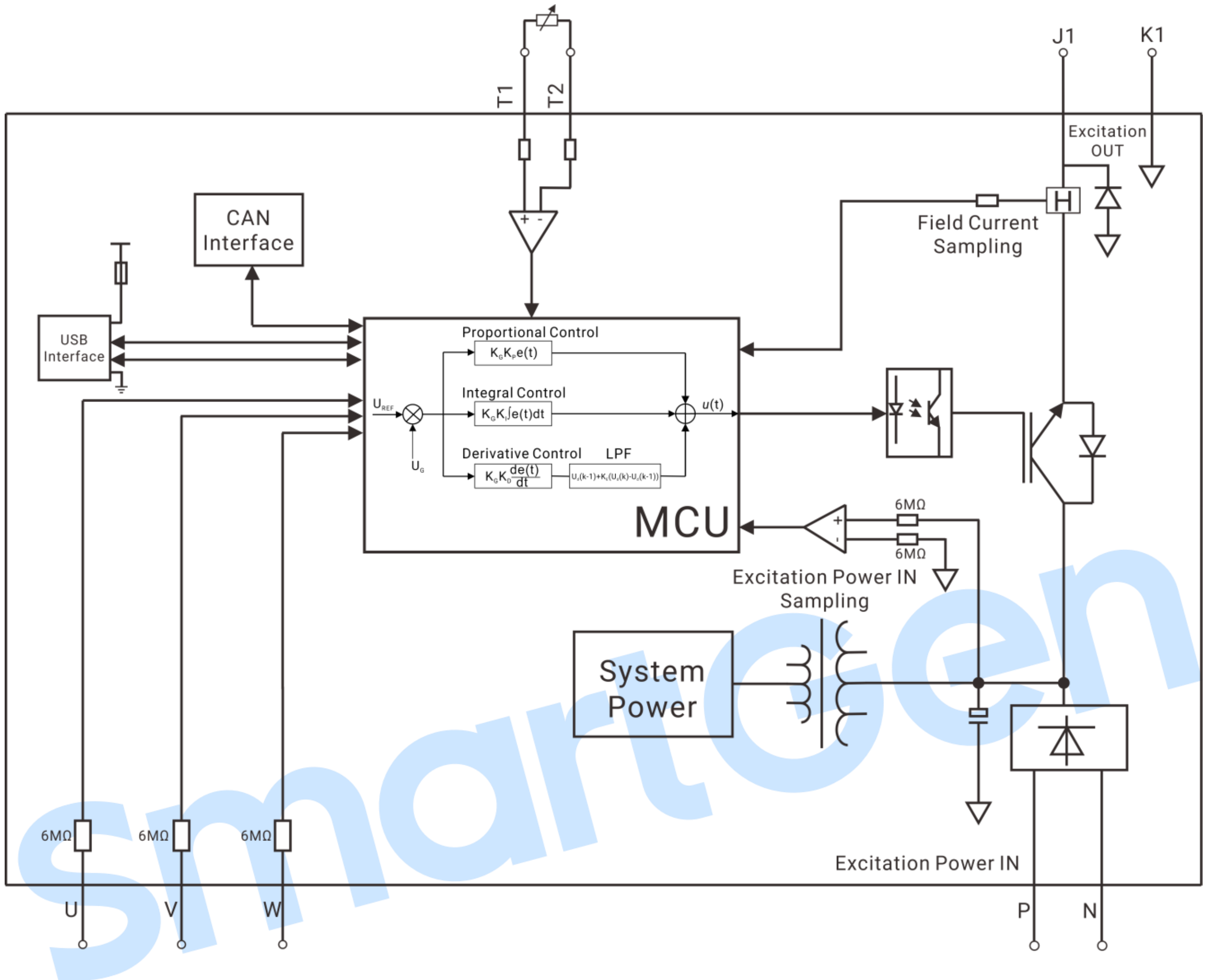


Fig.5 Schematic Diagram

5.2.2 START

Soft Start Mode

This function can control the change rate of generator voltage, as shown in Figure 6.

Soft start time: (0.1~120.0)s, default is 3s, it is the time from soft starting to reaching 100% target value.

Start threshold: (0.1~100.0)%, default is 20%, when generator voltage reaches the start threshold, it starts to regulate automatically.

Initial duty cycle: (0~100.0)%, default is 0, it is the initial PWM value of excitation regulation.

U/F characteristic of the generator is still active and has the priority to control generator voltage during soft starting.

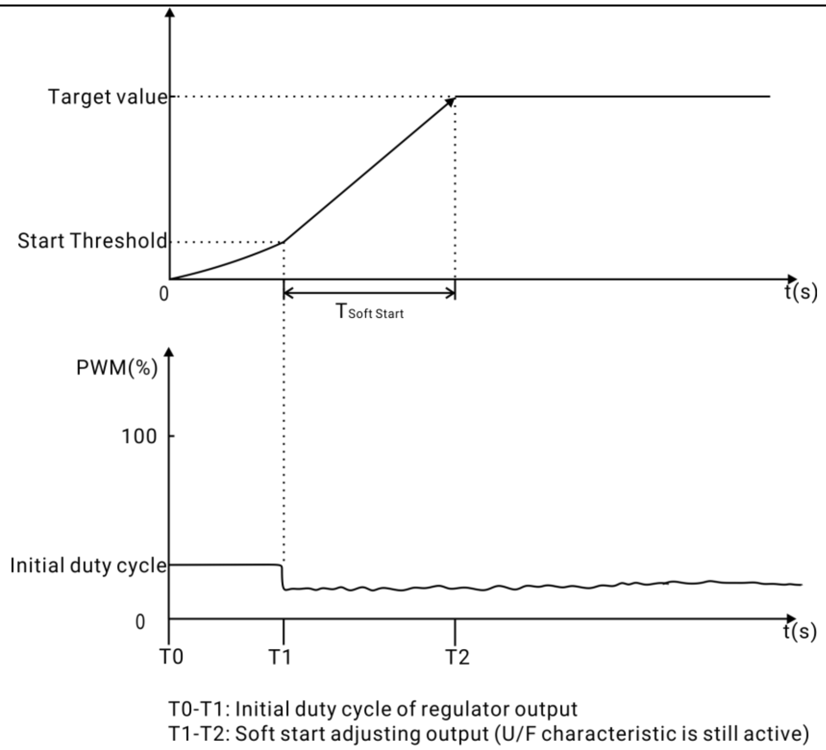


Fig.6 Soft Start Curve Diagram

Threshold Start Mode

The initial duty cycle of voltage regulator outputs setting. When the voltage regulator detects that generator voltage is greater than the pre-set start threshold, voltage regulation starts to activate. The target voltage is adjusted according to pre-set U/F characteristic.

Excitation stop condition: when generator frequency is lower than pre-set value, and excitation power input voltage is lower than preset excitation stop power supply voltage threshold, after the delay is over, and excitation will stop.

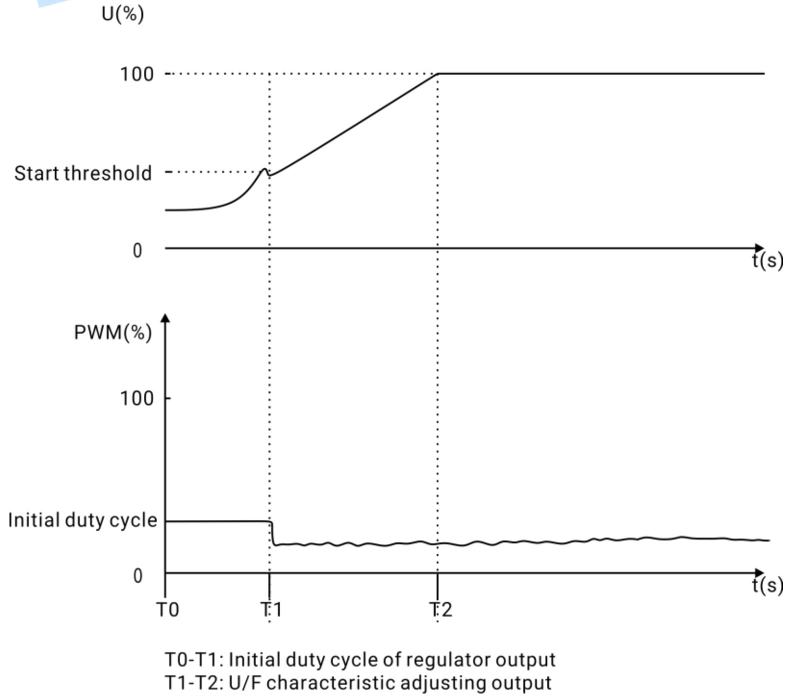


Fig.7 Threshold Start Curve Diagram

5.2.3 AUTOMATIC VOLTAGE REGULATION (AVR)

5.2.3.1 ILLUSTRATION OF ADJUSTING OUTPUT VOLTAGE

There are three methods to adjust AVR output voltage:

Method 1: Set AVR output voltage on PC Software (fixed set value)

For example:

If the Gen. Voltage Fixed Set Value is enabled on PC software, the gen. rated voltage is set as 400V, and the AVR output voltage is 100%, so that the generator output voltage is 400V (RMS).

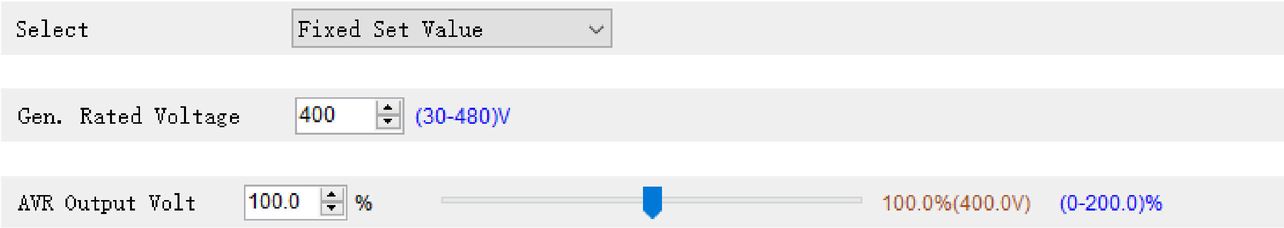


Fig.8 Fixed Output Voltage Configured on PC Software

In the same way, if the gen. rated voltage is set as 400V, and the AVR output voltage is 95%, so that the generator output voltage is 380VAC (RMS).

Method 2: Adjusting by potentiometer

If the Gen. Voltage External Selection is enabled on PC software, then write the configuration to HVR620, and adjust the output voltage by turning the potentiometer on HVR620.

For example:

Set the clockwise limit as 420V, the maximum voltage of clockwise potentiometer adjustment is 420V. Set the counterclockwise limit as 380V, the minimum voltage of counterclockwise potentiometer adjustment is 380V.

Fig.9 Output Voltage Configured by Potentiometer

Method 3: AVR fine tuning setting

Based on the method 1 and 2, the output voltage can be fine-tuned via CAN communication.

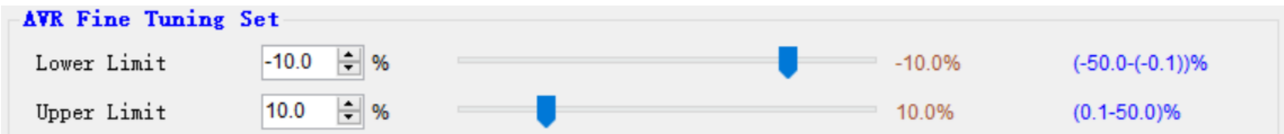


Fig.10 AVR Fine Tuning Setting on PC Software

For example:

If the current AVR output voltage is 400V, when a CAN data frame with the message ID 0x0C100211 and data 58 1B 00 00 00 00 00 is received:

Convert 0x1B58 (hexadecimal) into 7000 (decimal), 7000*(0.01%) = 70.00%;

Fine-tuning deviation of CAN communication (EC) = -10%+ (10% - -10%)*70.00% = 4.0%;

Target voltage value = 400*(100%+EC)= 416V.

⚠**NOTE 1**: This current command remains valid during AVR operation until a new CAN adjustment command is received.

⚠**NOTE 2**: Method 1 and Method 2 can not be effective at the same time, only one can be selected.

5.2.3.2 U/F SLOPE CHARACTERISTIC

There are two methods to adjust the U/F curve:

Method 1: Corner frequency curve is set as Not Used

For example:

Fig.11 PC Configuration of Curve

Start frequency (F_{start}): (10.0~100.0)%, default is 10.0%.

Knee frequency (F_{knee}): (70.0~100.0)%, default is 96.0%.

U/F slope (SLOPE): (0.5~5.0)%/Hz, default is 1.0 %/Hz. For every 1 Hz change in gen. frequency, change the gen. voltage by SLOPE%. U/F characteristic diagram is shown as below.

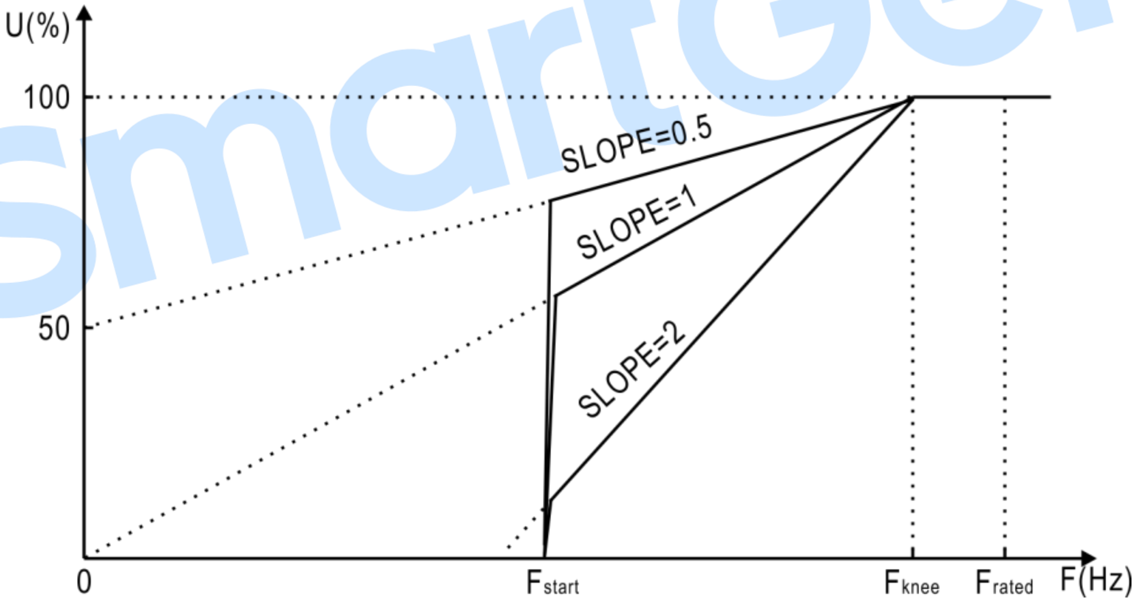


Fig.12 U/F Characteristic

Method 2: Corner frequency curve is set as Custom Curve

Set the curve as custom curve, and user can click the [button] button to set the U/F Characteristic curve. After setting, the voltage change of DVR corresponds to the pre-set frequency curve, and a maximum of 8 coordinate points can be configured, as shown in Figure 13.

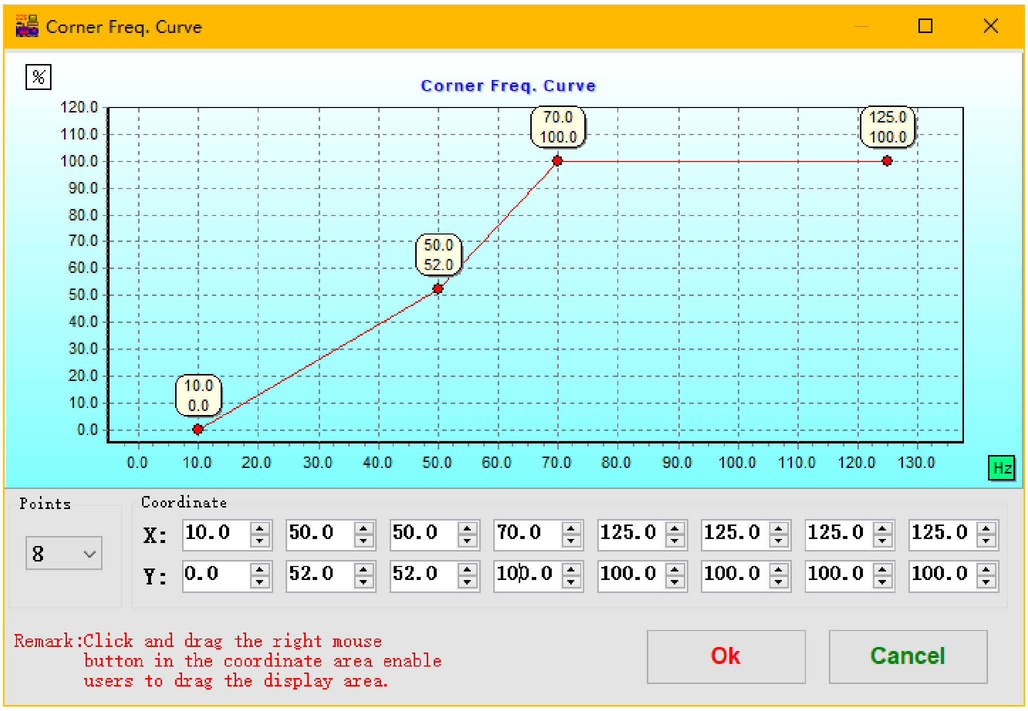


Fig.13 Corner Frequency Curve Setting

5.2.3.3 LOAD COMPENSATION FUNCTION

Drop value (U_{lcf}): (70.0~100.0)%, default is 90.0%.

Continuous delay (T_{lcf}): (0~10.0)s, default is 1s.

Rise slope (T_{rise}): (0.0~100.0)%/s, default is 0.2%/s.

When gen frequency drops to knee frequency (F_{knee}), target voltage drops to set voltage (U_{lcf}), it instantly reduces engine output power. When the frequency begins to rise, target voltage gradually rises according to T_{rise} setting, the unit's sudden loading performance is improved. When T_{lcf} delay is over, the load compensation is completed. U/F characteristic of the generator is still active and has priority to control generator voltage during load compensation.

This function is applicable to the occasion that sudden loading performance improvement by reducing the generator terminal voltage and output power in sudden loading.

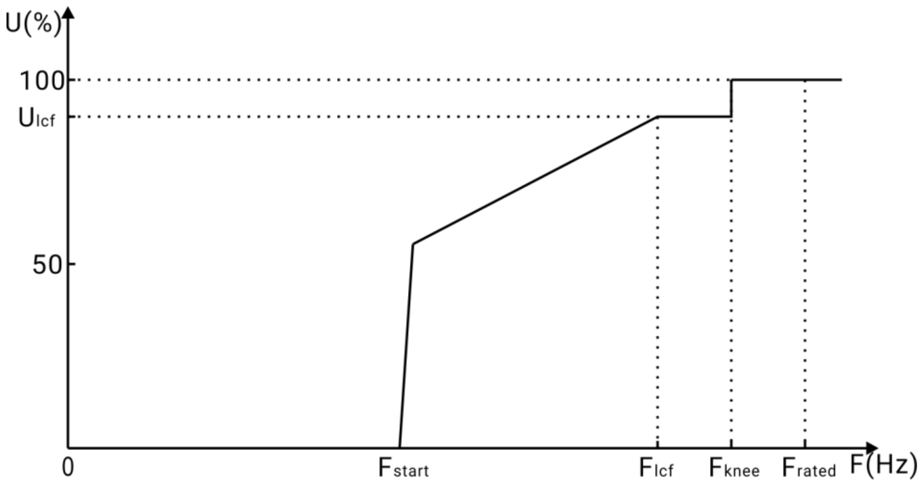
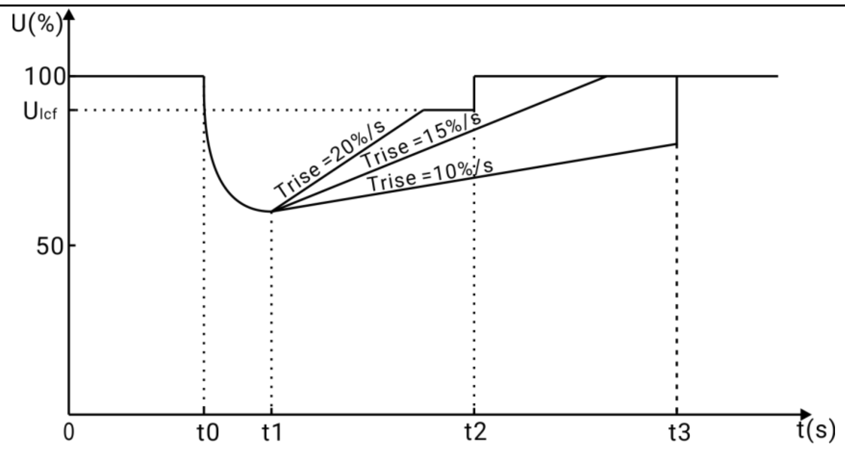


Fig.14 U/F Curve During Load Compensation



t0: Gen frequency < load compensation frequency($F<F_{lcf}$)

t1: Gen frequency > load compensation frequency($F>F_{lcf}$)

t2: Gen frequency > knee frequency ($F>F_{knee}$)

t3: End of duration ($t3=t1+T_{lcf}$)

Fig.15 Voltage/Time Curve During Load Compensation

5.2.3.4 RUNNING PROCESS

a) When generator is running, voltage regulator outputs initial duty cycle; when generator terminal voltage is higher than set start threshold voltage, soft starting begins for voltage regulation and excitation output is gradually increased;

b) After soft starting, regulate excitation output according to U/F curve; when gen frequency is higher than knee frequency, voltage regulator is adjusted with the rated voltage as the target;

c) When generator stops, excitation output is gradually stopping,; when gen frequency is lower than excitation stopping frequency, this running is finished;

d) When voltage regulator detects fault shutdown alarm, excitation output stops.

6 PROTECTION AND LIMIT

6.1 WARNING ALARM

When the voltage regulator detects the warning signal, it only sends warning and does not stop the excitation output.

Table 10 Warning Alarm

No.	Warning	Description
1	Gen Over Voltage	When gen over voltage alarm detection is enabled and regulator detects that gen terminal voltage is higher than threshold, it will send warning alarm signal. It is always detected.
2	Gen Under Voltage	When gen under voltage alarm detection is enabled and regulator detects that gen terminal voltage is lower than threshold, it will send warning alarm signal. It is detected after gen frequency is higher than knee frequency firstly.
3	Gen Over Frequency	When gen over frequency alarm detection is enabled and regulator detects that gen frequency is higher than threshold, it will send warning alarm signal. It is always detected.
4	Gen Under Frequency	When gen under frequency alarm detection is enabled and regulator detects that gen frequency is lower than threshold, it will send warning alarm signal. It is detected after gen frequency is higher than knee frequency firstly.
5	Excitation Over Current	When over-excitation limit is enabled and regulator detects that field current is higher than threshold 1 or over-excitation limit is active and action is warning, it will send warning alarm signal. It is always detected.
6	Excitation Over Voltage	When excitation over voltage detection is enabled and regulator detects that excitation voltage is higher than threshold, it will send warning alarm signal. It is always detected.
7	Unbalanced Voltage	When unbalanced voltage detection is enabled and regulator detects that unbalanced voltage is higher than threshold, it will send warning alarm signal. It is always detected.
8	No Power Generation	When no power generation alarm detection is enabled and regulator detects that gen voltage and frequency are both 0, it will send warning alarm signal. It is detected after gen frequency is higher than knee frequency or field current is higher that threshold for the first time.
9	Large THDu	When voltage waveform distortion detection is enabled and regulator detects that gen THDu is higher than pre-set warning threshold, it will send warning alarm signal. It is always detected.
10	Gen Loss of Phase	When gen loss of phase detection is enabled and regulator detects that gen phase is lost, it will send warning alarm signal. It is detected when gen voltage is higher than 50V.
11	Gen Reverse Phase	When gen reverse phase sequence detection is enabled and regulator

No.	Warning	Description
	Sequence	detects that gen phase sequence is reverse, it will send warning alarm signal. It is detected when gen voltage is higher than 50V.
12	Rotating Diode Open	When rotating diode open circuit detection is enabled and regulator detects that field current harmonic is higher than threshold (default is 5%), it will send warning alarm signal. It is always detected.
13	Rotating Diode Short Circuit	When rotating diode short circuit detection is enabled and regulator detects that field current harmonic is higher than threshold (default 10%), it will send warning alarm signal. It is always detected.
14	High Heat sink Temp.	When high heat sink temperature detection is enabled and the temperature of heat sink is higher than pre-set threshold (default is 110°C), regulator will send warning alarm signal. It is always detected.
15	High Winding Temp.	When high winding temperature detection is enabled and the temperature of winding is higher than pre-set threshold (default is 165°C), regulator will send warning alarm signal. It is always detected.

NOTE: When poles ratio (exciter poles/generator poles) is not equal to 0, field current harmonic is the sum of two harmonic values whose pole ratio is close to each other; when it is equal to 0, field current harmonic is the sum of each harmonic value. For example, the pole ratio of exciter with 14 poles and generator with 4 poles is 2.33, which is the percentage sum of harmonic 2 and 3.

6.2 FAULT ALARM

When the voltage regulator detects the fault alarm signal, it will stop excitation output at once and display alarm types.

Table 11 Fault Alarm

No.	Fault	Description
1	Gen Over Voltage	When gen over voltage alarm detection is enabled and regulator detects that gen terminal voltage is higher than threshold, it will send fault alarm signal. It is always detected.
2	Gen Under Voltage	When gen under voltage alarm detection is enabled and regulator detects that gen terminal voltage is lower than threshold, it will send fault alarm signal. It is detected after gen frequency is higher than knee frequency firstly.
3	Gen Over Frequency	When gen over frequency alarm detection is enabled and regulator detects that gen frequency is higher than threshold, it will send fault alarm signal. It is always detected.
4	Gen Under Frequency	When gen under frequency alarm detection is enabled and regulator detects that gen frequency is lower than threshold, it will send fault alarm signal. It is detected after gen frequency is higher than knee frequency firstly.
5	No Power	When no power generation alarm detection is enabled and regulator detects

No.	Fault	Description
	Generation	that gen voltage and frequency are both 0, it will send fault alarm signal. It is detected after gen frequency is higher than knee frequency firstly or field current is higher that threshold.
6	Excitation Over Current	When over-excitation limit is enabled, over-excitation limit is active and action is shutdown, it will send fault alarm signal. It is always detected.
7	Excitation Over Voltage	When excitation over voltage detection is enabled and regulator detects that excitation voltage is higher than threshold, it will send fault alarm signal. It is always detected.
8	Unbalanced Voltage	When unbalanced voltage detection is enabled and regulator detects that unbalanced voltage is higher than threshold, it will send fault alarm signal. It is always detected.
9	Large THDu	When voltage waveform distortion detection is enabled and regulator detects that THDu is higher than threshold, it will send fault alarm signal. It is always detected.
10	Rotating Diode Open	When rotating diode open circuit detection is enabled and regulator detects that field current harmonic is higher than threshold, it will send fault alarm signal. It is always detected.
11	Rotating Diode Short Circuit	When rotating diode short circuit detection is enabled and regulator detects that field current harmonic is higher than threshold, it will send fault alarm signal. It is always detected.
12	High Heat sink Temp.	When high heat sink temperature detection is enabled and the temperature of heat sink is higher than pre-set threshold (default is 110°C), regulator will send fault alarm signal. It is always detected.
13	High Winding Temp.	When high winding temperature detection is enabled and the temperature of winding is higher than pre-set threshold (default is 165°C), regulator will send fault alarm signal. It is always detected.

6.3 OVER EXCITATION LIMIT

It will cause excitation winding overheating when generator runs in the over excitation range of power characteristic curve. Therefore, generator needs to recover system voltage to provide more reactive power to it, that is, forced excitation capability. There are 2 excitation overcurrent threshold can be set for over excitation limit, overcurrent 2 threshold is forced excitation limit value, overcurrent 1 threshold is long-time allowing field current. The regulator can limit forced field current instantly. When forced excitation limit is active, field current will be limited less than 0.95 times the excitation overcurrent 2 threshold; when field current exceeds overcurrent 1 threshold and reaches over-excitation inverse time, over-excitation limit of field current will be active and then field current will be limited less than 0.95 times the excitation overcurrent 1 threshold, waiting for accumulated heat to release.

Action can be set when over-excitation limit is active, regulator will issue warning or fault alarm after delaying set over-excitation limit time.

Calculation method of over-excitation inverse time:

Determine inverse time limit curve via excitation overcurrent 1 threshold, overcurrent 2 threshold.

The calculation formula is: $$t=\frac{I_{FEL}^2 - I_{OEL}^2}{I_E^2 - I_{OEL}^2}Tq$$.

Definition: I_{FEL} (forced excitation limit value) --- excitation overcurrent 2 threshold

T_q (forced excitation allowing time) --- overcurrent delay

I_{OEL}(over-excitation limit value) --- excitation overcurrent 1 threshold

I_E --- actual field current t --- calculation value of inverse time

Over-excitation limiting method:

Over-excitation limiting is carried out by comparing the calculated heat accumulation $B=\int(I_E^2-I_{OEL}^2)dt$ with the maximum allowing heat accumulation $B_0=(I_{FEL}^2-I_{OEL}^2)Tq$. When heat accumulation B≥B0 or accumulation time of over-excitation reaches the maximum delay time, over-excitation limit is active.

Heat accumulation calculation:

1) B=0, $I_E \le I_{OEL}$, over-excitation never occurred, no overheating accumulated;
2) B=0, $I_E > I_{OEL}$, over-excitation never occurred, current over-excitation, heat accumulation: $B = B+(I_E^2-I_{OEL}^2)\Delta t$;
3) B>0, $I_E > I_{OEL}$, over-excitation never occurred, current over-excitation, heat accumulation: $B = B+(I_E^2-I_{OEL}^2)\Delta t$;
4) B>0, $I_E < I_{OEL}$, over-excitation has occurred, there is no over-excitation at present, and the heat is accumulated in the reverse direction: $B = B+(I_E^2-I_{OEL}^2)\Delta t$, that is, the heat release process. When B≤0, the calculation is cut off, B=0.

When over-excitation limit is active, field current will be limited less than 0.95 times the excitation overcurrent 1 threshold, heat will be released until it is over (B=0), and forced excitation again is not allowed during this process.

For example:

Fig.16 Over-excitation Limit Setting on PC Software

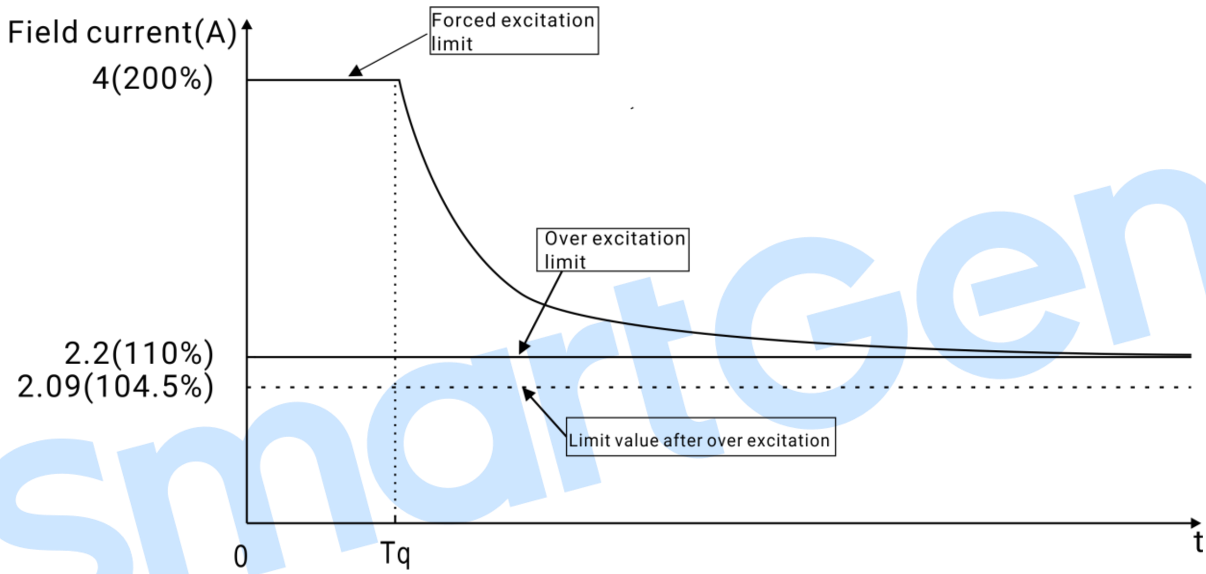


Fig.17 Over-excitation Limit Setting

6.4 LOWER VOLTAGE OUTPUT

High heat sink temperature protection:

During the AVR operation, if the heat sink temperature exceeds its forced action value, the AVR will immediately stop the excitation output and issue the high heat sink temperature fault alarm. If the heat sink temperature exceeds its set value but does not reach its forced action value, the AVR will reduce its output voltage by 5.5% from the rated voltage. After a 1-minute delay, if the heat sink temperature still exceeds its set value, the AVR will stop the excitation output and issue the high heat sink temperature fault alarm. If the AVR heat sink temperature remains between the set value and return value after another 1-minute delay, the AVR will keep reducing the output voltage. During the voltage reduction operation, if the heat sink temperature drops below the return value, the AVR output voltage will restore to the rated voltage.

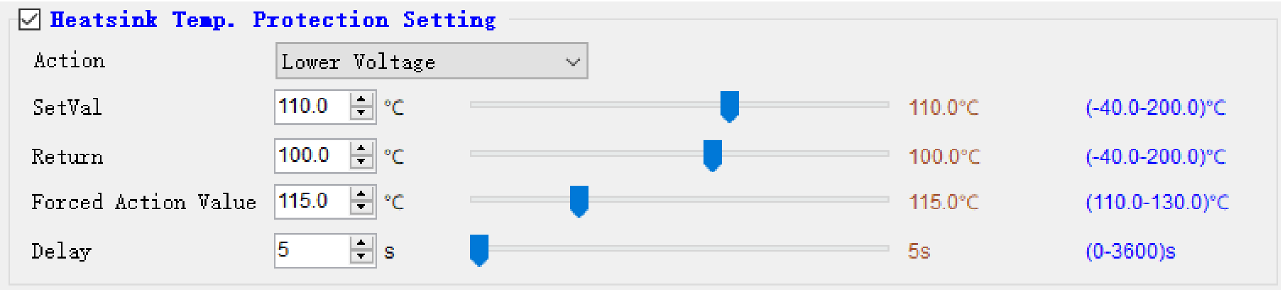


Fig.18 Heat Sink Temperature Protection Setting

High winding temperature protection:

During the AVR operation, if the winding temperature exceeds its forced action value, the AVR will immediately stop the excitation output and issue the high winding temperature fault alarm. If the winding temperature exceeds its set value but does not reach its forced action value, the AVR will reduce its output voltage by 5.5% from the rated voltage. After a 1-minute delay, if the winding temperature still exceeds its set value, the AVR will reduce its output voltage by further 5.5% (11% in total). After another 1-minute delay, if the winding temperature still exceeds its set value, the AVR will stop the excitation output and issue the high winding temperature fault alarm. During the output voltage reduction operation, if the AVR winding temperature remains between the set value and return value after a 1-minute delay, the AVR will keep reducing the output voltage. If the winding temperature exceeds its set value again during the voltage reduction operation, the AVR will reduce its output voltage by further 5.5% (when it has already reduced 5.5%) or stop the excitation output (when it has already reduced 11%). During the output voltage reduction operation, if the winding temperature drops below the return value, the AVR output voltage will restore to the rated voltage.

NOTE: When both heat sink and winding protection trigger the voltage reduction simultaneously, the larger voltage reduction value shall prevail.

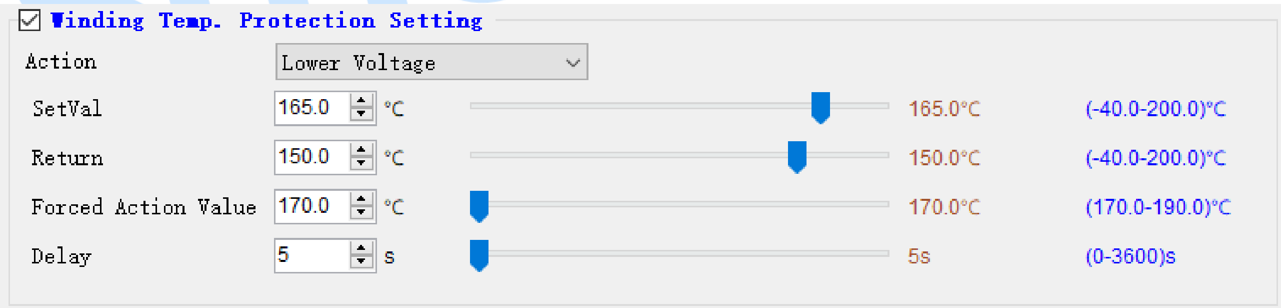


Fig.19 Winding Temperature Protection Setting

7 CONFIGURABLE PARAMETERS RANGE AND DEFINITION

Table 12 Parameters Setting and Range

No.	Item		Range	Default	Description
Module Setting					
1	Password Setting		(0-9999)	0318	
2	Module Address		(1-254)	17	Source address of CAN request.
3	Alarm Data Record Interval		(0-60.0) s	0.1	
4	J1939-75 Transmission Enable		(0-1)	0	0: Disable; 1: Enable.
System Setting					
1	Gen Rated Voltage Potentiometer Option		(0-1)	0	0: Gen. Voltage Fixed Value 1: Gen. Voltage External Selection
2	Gen Rated Voltage		(30-480) V	400	Standard for gen over/under voltage, gen target voltage.
3	Counterclockwise Limit		(30-480)V	380	
4	Clockwise Limit		(30-480)V	420	
5	Gen Rated Frequency		(10.0-200.0)Hz	50.0	
6	Generator Poles		(1-64)	4	Poles ratio = exciter poles/gen poles; It is for rotating diode fault detection.
7	Exciter Poles		(0-64)	0	
Excitation Setting					
1	Rated Voltage		(0-200) V	63	Rated excitation voltage, standard for excitation over/under voltage.
2	Over Voltage 1 Setting	Enable	(0-1)	1	0: Disable; 1: Enable. Set value is the percentage of rated excitation voltage. Return value is the percentage of rated excitation voltage Delay value. Action: 0: None; 1: Warning; 2: Fault.
		Set Value	(0-200.0) %	120	
		Return	(0-200.0) %	116	
		Delay	(0-3600) s	3	
		Action	(0-2)	2	
3	Over Voltage 2 Setting	Enable	(0-1)	1	
		Set Value	(0-200.0) %	110	
		Return	(0-200.0) %	108	
		Delay	(0-3600) s	5	
		Action	(0-2)	1	
4	Rated Current		(0-10) A	5.0	Rated field current, standard for over-excitation limit.
5	Over Excitation Limit 1 (OEL)	Enable	(0-1)	0	0: Disable; 1: Enable
		Overcurrent 1	(0-300.0) %	110	The threshold is the percentage of rated field current.
		Overcurrent 2	(0-300.0) %	200	
		Delay	(1-120)s	10	Delay value.
		Over-excitation Action	(0-2)	1	Action: 0: None; 1: Warning; 2: Fault.
		Over-excitation Delay	(0-3600) s	10	Delay value.

No.	Item		Range	Default	Description
6	Short Circuit Setting of Rotating Diode	Enable	(0-1)	0	0: Disable; 1: Enable. Set value is the percentage of field current harmonic. Return value is the percentage of field current harmonic. Delay value. Action: 0: None; 1: Warning; 2: Fault.
		Set Value	(0-100.0) %	10	
		Return	(0-100.0) %	9	
		Delay	(0-3600) s	1	
		Action	(0-2)	2	
7	Open Circuit Setting of Rotating Diode	Enable	(0-1)	0	
		Set Value	(0-100.0) %	5	
		Return	(0-100.0) %	4	
		Delay	(0-3600) s	5	
		Action	(0-2)	2	
8	Heat sink Temp. Protection Setting	Enable	(0-1)	1	0: Disable; 1: Enable.
		Set Value	(-40-200)°C	110	Set value
		Return	(-40-200)°C	100	Return value
		Delay	(0-3600)s	5	Delay value
		Action	(0-3)	3	Action: 0: None; 1: Warning; 2: Fault. 3: Lower voltage.
		Forced Action	(110-130)°C	115	Forced action value to stop the excitation output.
9	Winding Temp. Protection Setting	Enable	(0-1)	1	0: Disable; 1: Enable.
		Set Value	(-40-200)°C	165	Set value
		Return	(-40-200)°C	150	Return value
		Delay	(0-3600)s	5	Delay value
		Action	(0-3)	3	Action: 0: None; 1: Warning; 2: Fault. 3: Lower voltage.
		Forced Action	(170-190)°C	170	Forced action value to stop the excitation output.
Generator Setting					
1	Reverse Phase Seq. Detect		(0-1)	0	0: Disable; 1: Enable
2	Loss of Phase Detect		(0-1)	0	0: Disable; 1: Enable
3	Gen Over Voltage Alarm 1	Enable	(0-1)	1	0: Disable; 1: Enable. Set value is the percentage of gen rated voltage. Return value is the percentage of gen rated voltage. Delay value. Action: 0: None; 1: Warning; 2: Fault.
		Set Value	(0-200.0) %	120	
		Return	(0-200.0) %	118	
		Delay	(0-3600) s	3	
		Action	(0-2)	2	
4	Gen Over Voltage Alarm 2	Enable	(0-1)	1	
		Set Value	(0-200.0) %	110	
		Return	(0-200.0) %	108	
		Delay	(0-3600) s	5	
		Action	(0-2)	1	
5	Gen Under	Enable	(0-1)	0	

No.	Item		Range	Default	Description
	Voltage Alarm 1	Set Value	(0-200.0) %	80	
		Return	(0-200.0) %	82	
		Delay	(0-3600) s	3	
		Action	(0-2)	2	
6	Gen Under Voltage Alarm 2	Enable	(0-1)	0	
		Set Value	(0-200.0)%	84	
		Return	(0-200.0)%	86	
		Delay	(0-3600)s	5	
		Action	(0-2)	1	
7	Gen Over Frequency Alarm 1	Enable	(0-1)	1	0: Disable; 1: Enable Set value is the percentage of gen rated frequency. Return value is the percentage of gen rated frequency. Delay value. Action: 0: None; 1: Warning; 2: Fault.
		Set Value	(0-200.0%)	114	
		Return	(0-200.0%)	110	
		Delay	(0-3600s)	3	
		Action	(0-2)	2	
8	Gen Over Frequency Alarm 2	Enable	(0-1)	1	
		Set Value	(0-200.0) %	110	
		Return	(0-200.0) %	108	
		Delay	(0-3600) s	5	
		Action	(0-2)	1	
9	Gen Under Frequency Alarm 1	Enable	(0-1)	0	
		Set Value	(0-200.0) %	80	
		Return	(0-200.0) %	82	
		Delay	(0-3600) s	3	
		Action	(0-2)	2	
10	Gen Under Frequency Alarm 2	Enable	(0-1)	0	
		Set Value	(0-200.0) %	84	
		Return	(0-200.0) %	86	
		Delay	(0-3600) s	5	
		Action	(0-2)	1	
11	Gen Unbalanced Voltage 1	Enable	(0-1)	1	0: Disable; 1: Enable Set value is percentage of gen unbalanced voltage. Return value is percentage of gen unbalanced voltage. Delay value. Action: 0: None; 1: Warning; 2: Fault.
		Set Value	(0-200.0%)	10	
		Return	(0-200.0%)	5	
		Delay	(0-3600s)	5	
		Action	(0-2)	1	
12	Gen Unbalanced Voltage 2	Enable	(0-1)	0	
		Set Value	(0-200.0%)	10	
		Return	(0-200.0%)	5	
		Delay	(0-3600s)	5	
		Action	(0-2)	0	
13	Gen Waveform	Enable	(0-1)	0	0: Disable; 1: Enable Set value is waveform distortion
		Set Value	(0-200.0%)	10	

No.	Item		Range	Default	Description
	Distortion 1	Return	(0-200.0%)	5	degree of gen voltage. Return value is waveform distortion degree of gen voltage. Delay value. Action: 0: None; 1: Warning; 2: Fault.
		Delay	(0-3600s)	5	
		Action	(0-2)	0	
14	Gen Waveform Distortion 2	Enable	(0-1)	0	
		Set Value	(0-200.0%)	10	
		Return	(0-200.0%)	5	
		Delay	(0-3600s)	5	
		Action	(0-2)	0	
15	No Power Generation Alarm	Enable	(0-1)	1	0: Disable; 1: Enable
		Set Value	(0-100.0) %	30	Set value is the percentage of rated field current.
		Return	(0-100.0) %	10	
		Delay	(0-3600) s	2	Delay value.
		Action	(0-2)	2	Action: 0: None; 1: Warning; 2: Fault.
Excitation Mode					
1	Start Threshold		(0.1-100.0) %	20.0	The percentage of rated voltage.
2	Initial Duty Cycle		(0.0-100.0) %	0	Initial PWM duty cycle.
3	Soft Start Enable		(0-1)	0	0: Disable; 1: Enable.
4	Soft Start Time		(0.1-120) s	3	When this function is enabled, it is the transfer time of generator terminal voltage from soft start voltage to rated voltage.
5	Excitation Stop Condition	Frequency	(10.0-100.0) Hz	10.0	Frequency of excitation stopping.
		Supply Volt	(0-450.0) V	20.0	Power input voltage of excitation stopping.
		Delay	(0-3600) s	0	Delay value when the above two stop excitation conditions are met at the same time.
6	Threshold Start Mode		(0-1)	0	0: Disable; 1: Enable.
AVR Regulation Setting					
1	AVR Output Voltage		(0.0-200.0) %	100.0	Output voltage value is the percentage of rated voltage.
2	Fine-tuning Setting	Upper Limit	(0.1-50.0)%	10.0	Set value is the percentage of gen rated voltage.
		Lower Limit	(-50.0-(-0.1))%	-10.0	
3	Volt/Freq. (U/F) Set	Start Freq.	(10.0-100.0) %	10	Gen frequency when U/F characteristic starts.
		Knee Freq.	(70.0-100.0) %	96	Knee frequency of U/F characteristic.
		U/F Slope	(0.5-5.0) %/Hz	1.0	Slope of U/F characteristic. For every 1 Hz change in gen. frequency, change the gen. voltage by SLOPE%.

No.	Item		Range	Default	Description
		U/F Knee Curve Enable	(0-1)	0	0: Unused; 1: Custom curve.
		Knee Curve X1	(0-200.0)Hz	10.0	
		Knee Curve X2	(0-200.0)Hz	48.0	
		Knee Curve X3	(0-200.0)Hz	48.0	
		Knee Curve X4	(0-200.0)Hz	48.0	
		Knee Curve X5	(0-200.0)Hz	48.0	
		Knee Curve X6	(0-200.0)Hz	48.0	
		Knee Curve X7	(0-200.0)Hz	48.0	
		Knee Curve X8	(0-200.0)Hz	48.0	
		Knee Curve Y1	(0-100.0)%	0	
		Knee Curve Y2	(0-100.0)%	100.0	
		Knee Curve Y3	(0-100.0)%	100.0	
		Knee Curve Y4	(0-100.0)%	100.0	
		Knee Curve Y5	(0-100.0)%	100.0	
		Knee Curve Y6	(0-100.0)%	100.0	
		Knee Curve Y7	(0-100.0)%	100.0	
		Knee Curve Y8	(0-100.0)%	100.0	
4	Load Compensation (LCF)	Enable	(0-1)	0	0: Disable; 1: Enable.
		Drop Value	(70.0-100.0) %	90.0	Set value is the percentage of rated voltage.
		Delay	(0-10.0) s	1.0	Continuous time of load compensation.
		Rise Slope	(0-100.0) %/s	0.2	The percentage of the rated voltage rising per second.
PID Setting					
1	DC Compensation Enable		(0-1)	0	0: Disable; 1: Enable.
2	Input Voltage of Excitation Power Supply		(0-450.0) V	270	Unit: V
3	DC Compensation Factor		(1-10)	3	
4	Max Output Duty Cycle		(0-100.0) %	100.0	Max output duty cycle in excitation regulation.
5	Negative Excitation		(0-1)	0	0: Disable; 1: Enable.
PID Parameter					
1	AVR 1	KG Coefficient	(0-20.000) %	1.000	Coefficient of PID set value.
		KP Gain	(0-2000.0) %	20	PID set value of AVR mode. It works when gen frequency is below 100Hz.
		KI Stability	(0-2000.0) %	20	
		KD Derivative	(0-2000.0) %	0	
		KE Derivative Filter Coefficient	(0-20.000) %	1.000	Derivative filter coefficient.
2	AVR 2	KG Coefficient	(0-20.000) %	1.000	Coefficient of PID set value.
		KP Gain	(0-2000.0) %	20	PID set value of AVR mode.

No.	Item		Range	Default	Description
		KI Stability	(0-2000.0) %	20	It works when gen frequency is 100Hz and above.
		KD Derivative	(0-2000.0) %	0	
		KE Derivative Filter Coefficient	(0-20.000) %	1.000	Derivative filter coefficient.
3	FCR	KG Coefficient	(0-20.000)%	1.000	Coefficient of PID set value.
		KP Gain	(0-2000.0)%	20	PID set value when over excitation protection occurs.
		KI Stability	(0-2000.0)%	20	
		KD Derivative	(0-2000.0)%	0	
		KE Derivative Filter Coefficient	(0-20.000)%	1.000	Derivative filter coefficient.
CAN Communication Setting					
1	CAN Communication Enable		(0-1)	0	0: Disable; 1: Enable.
2	CAN Comm. Baud Rate		500kBit/s	250k	CAN communication baud rate.
			250kBit/s		
			125kBit/s		
			50kBit/s		

8 PARAMETER SETTING

It needs to input the same password with voltage regulator for parameter setting via PC software .

NOTES:

a) Voltage regulator needs to be powered on (USB power supply) for parameter setting.

b) Please modify the internal parameters in standby mode (like delay setting), otherwise fault alarm or other abnormal conditions may appear. PID parameters can be directly adjusted in running.

c) Higher threshold must be greater than the lower threshold, such as over voltage threshold must be greater than under voltage threshold; otherwise over voltage and under voltage will occur at the same time.

d) Please set return value correctly for warning alarm, otherwise, alarm will be abnormal; when setting higher warning, return value should be less than set value, when setting lower warning, return value should be greater than set value.

9 REAL-TIME DATA ANALYSIS

Real-time data curve analysis can be conducted via PC software. 8 parameters can be monitored at the same time, each monitoring parameter can set max value, min value, and specific parameter can be displayed by selecting the checkbox in front of the parameter (not displayed when not selected). The following diagram shows data analysis interface.

Click “Start” button to initiate data monitoring, click “Pause” button to pause data monitoring, and click “Stop” button to stop data monitoring. Click “Save CSV” or “Save XML” button can save the curve as csv or xml file, click “Load CSV” button can load and view the saved CSV curve file.

Sampling interval of real-time data is fixed as 10ms.

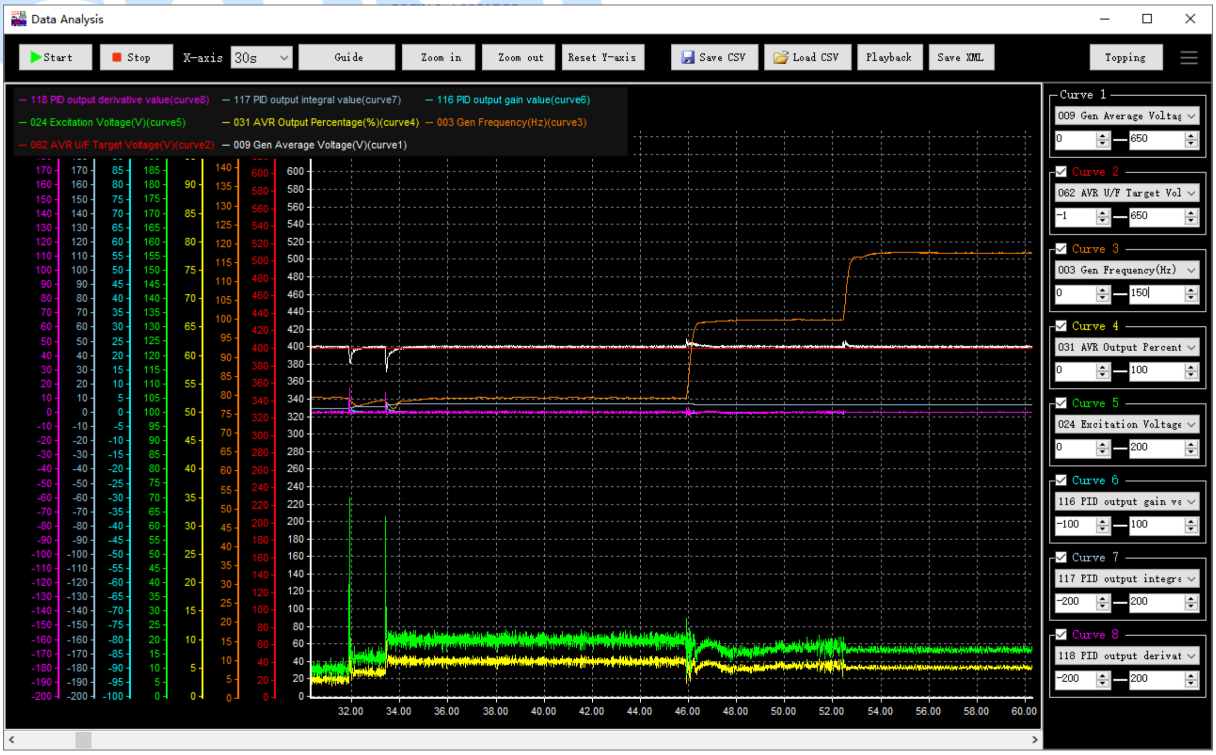


Fig.20 Real-time Data Analysis Diagram on PC Software

10 COMMISSIONING

- Check all the connection wires are correct and wires diameter is suitable.
- Set parameter (gen rated parameters, etc.) through USB interface via PC software.
- Enable the threshold start mode, set initial duty cycle and proper PID parameter, and take appropriate protective measures, then start the genset. When gen voltage reaches start voltage, the voltage regulator enters soft start status. After soft starting, regulate PWM duty cycle and stabilize generator terminal voltage automatically according to U/F characteristic.
- When the regulator is working normally, sudden load/unload test can be conducted, check the voltage curve, and adjust PID parameters to meet dynamic characteristic demand of generator.
- If there are any other questions, please contact SmartGen's service.

11 TYPICAL APPLICATION

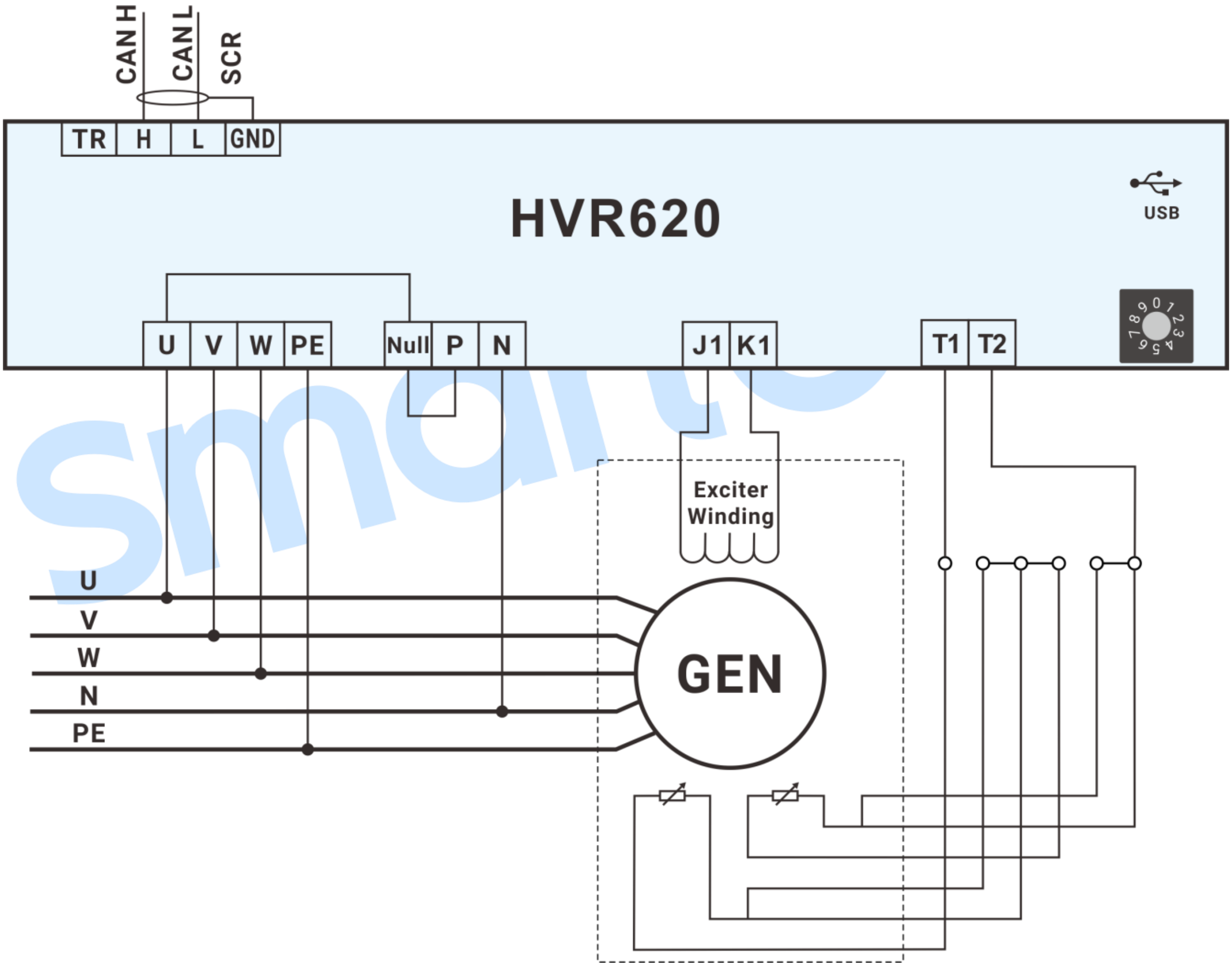


Fig.21 SHUNT Generator Typical Application

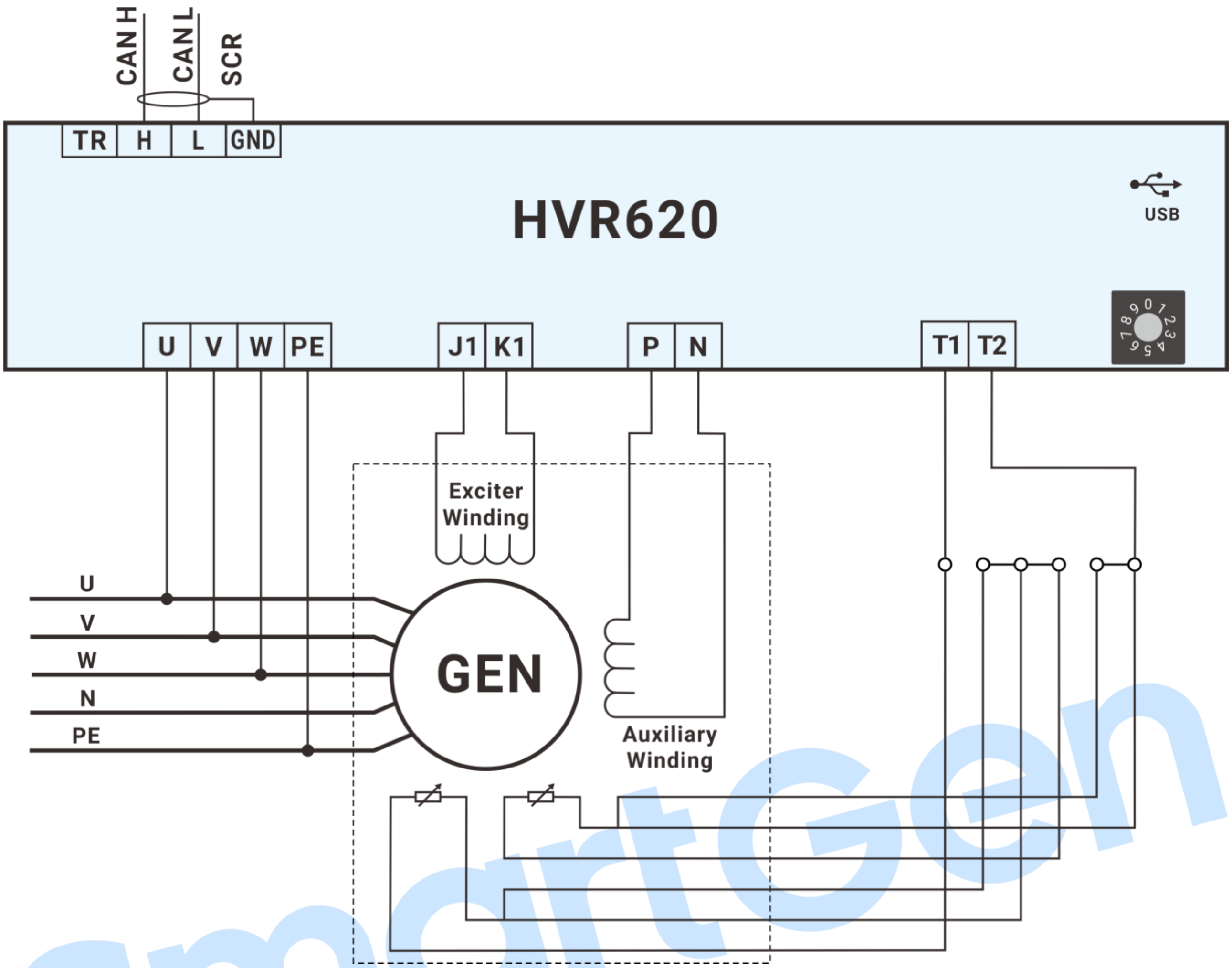


Fig.22 AUXW Generator Typical Application

12 INSTALLATION

12.1 OVERALL AND INSTALLATION DIMENSIONS

Unit: mm

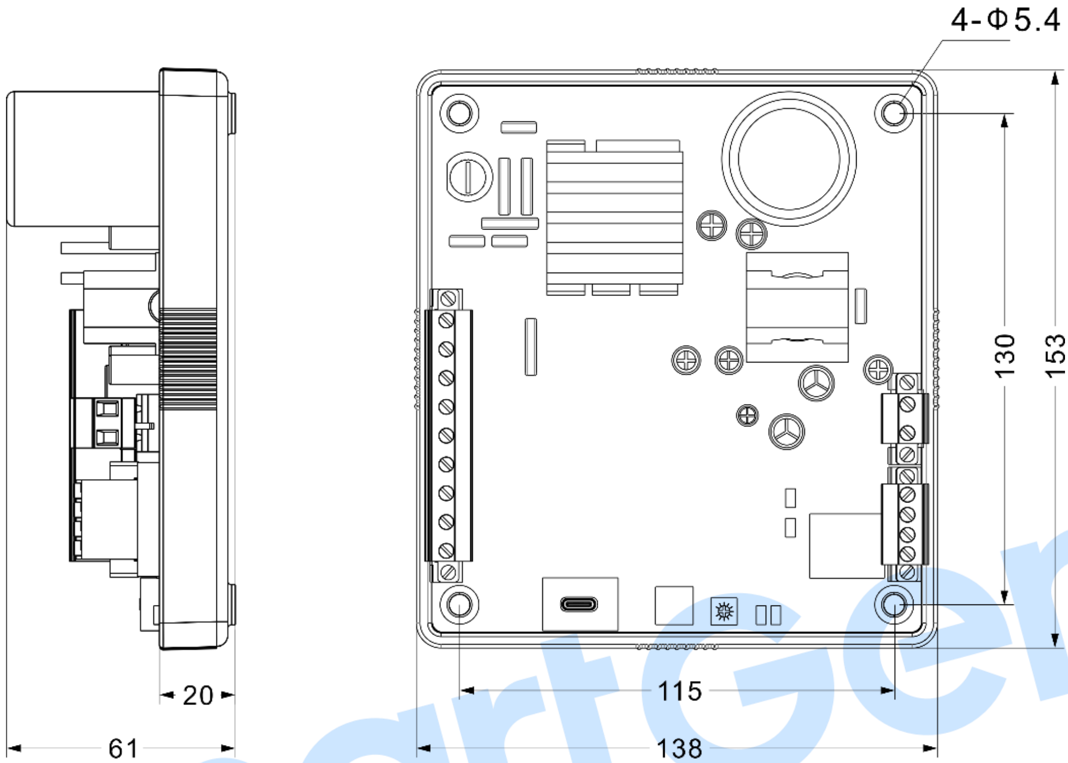


Fig.23 Overall and Installation Dimension

12.2 INSTALLATION METHOD AND RECOMMENDATION

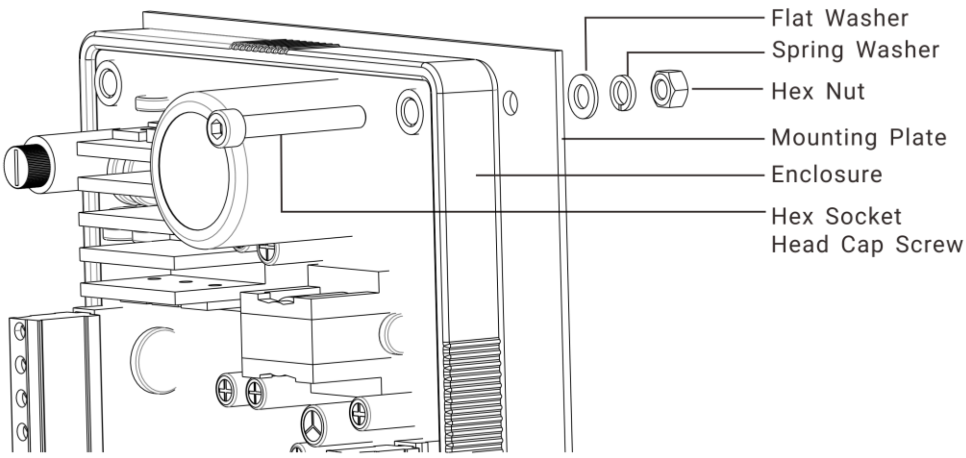
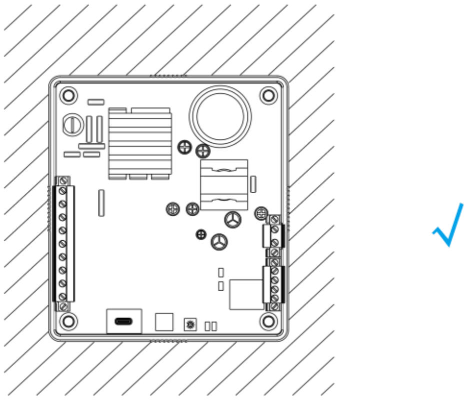


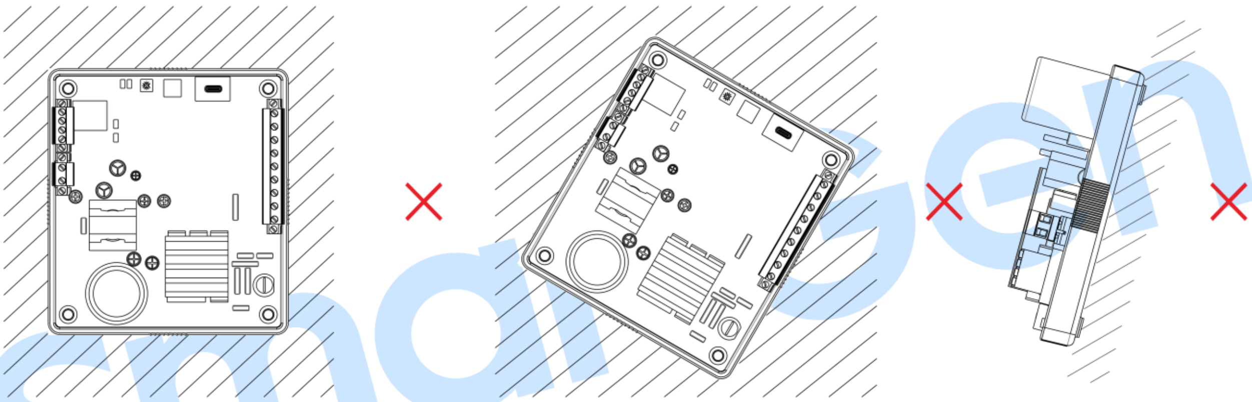
Fig.24 Installation Method

Installation Recommendation



Horizontal Installation
Heat Sink on the TOP

Forbidden Installation



Horizontal Installation
Heat Sink on the BOTTOM

Tilled Installation

Inclined Installation

Fig.25 Installation Recommendation

13 FAULT FINDING

Table 13 Fault Finding

Symptoms	Possible Solutions
Regulator Non-operation Gen Voltage Unavailable	Check if the power connections are normal; Check if the power fuse is normal.
Gen Voltage Low	Check if the set rated gen voltage is correct; Check if the set U/F characteristic slope is correct; Check if the generator is running at rated speed.
Gen Voltage High	Check if the set rated gen voltage is correct; Check if the set U/F characteristic slope is correct; Check if the generator is running at rated speed.
Gen Voltage Instability	Check if the connections of gen terminal voltage are normal; Check if the PID parameter setting is proper, adjust PID parameter.
CAN Communication Failure	Check wiring connections; Check if the CAN baud rate is correct; Check if H and L line of CAN interface is connected reversely; 120Ω resistor between Terminal CAN H and L of voltage regulator is recommended, which can be realized by shorting Terminal TR and H.

14 APPENDIX I (CAN COMMUNICATION PROTOCOL)

Table 14 Request Data Message

Message ID	Item	Cycle	Remarks
0x0CFDFD11	Generator W-Phase Electrical Energy	100ms	Refer to the table below for details.
0x0CFE0011	Generator V-Phase Electrical Energy	100ms	
0x0CFE0311	Generator U-Phase Electrical Energy	100ms	
0x0CFE0611	Gen Average AC Electrical Energy	100ms	
0x0C100011	Alarm and Status	100ms	

Table 15 Request Message Parameter Details

Message ID	Parameter	Location	Bit Length	Resolution	Offset	Note
0x0CFDFD11	Gen WU Line Voltage	1.1	16	1V/bit	0	
	Gen Frequency	5.1	16	1/128Hz/bit	0	
0x0CFE0011	Gen VW Line Voltage	1.1	16	1V/bit	0	
	Gen Frequency	5.1	16	1/128Hz/bit	0	
0x0CFE0311	Gen UV Line Voltage	1.1	16	1V/bit	0	
	Gen Frequency	5.1	16	1/128Hz/bit	0	
0x0CFE0611	Gen Average Line Voltage	1.1	16	1V/bit	0	
	Gen Frequency	5.1	16	1/128Hz/bit	0	
0x0C100011	Fault Alarm	2.1	1	/	0	0 No Alarm 1 Fault Alarm
	Warning Alarm	3.1	1	/	0	0 No Warning Alarm 1 Warning Alarm

Table 16 Received Data Message

Message ID	Item	Cycle	Remark
0x0C100211	AVR Mode Parameter	10ms	
Remarks: If no new data is received within the specified cycle, parameters received last time are retained.			

Table 17 Received Message Parameter Details

Message ID	Parameter	Location	Bit Length	Accuracy	Offset	Note
0x0C100211	Fine-tuning Deviation of Output Voltage	1.1	16	0.01%/bit	0%	(0-100.00)%

⚠**NOTE:** CAN message is encoded in Intel format, with the lowest byte first.

Example of target voltage parameter calculation:

If the gen. rated output voltage is 400V, the AVR fine-tuning pre-set lower limit is -10% (-40V), and the pre-set upper limit is 10% (40V). The required output voltage is 380V, and the voltage deviation is (380-400=-20V), the deviation value is (-20-(-40))/(40-(-40)) = 25%.

CAN request target value: 25%/(0.01%) = 2500, convert 2500 (decimal) into 0x09C4 (hexadecimal).

CAN request message: ID: 0x0C100211, Data: C4 09 00 00 00 00 00 00.

15 APPENDIX II SYMBOL AND TERM DEFINITION

Table 18 Symbol and Term Definition

Symbol	Term	Remark
AVR	Automatic voltage regulation mode	
LCF	Load compensation function	
F_{start}	Start frequency	
F_{knee}	Knee frequency	
F_{lcf}	Load compensation frequency	
F_{rated}	Rated frequency	
SLOPE	U/F slope	U/F characteristic.
U_{lcf}	Load compensation voltage	Load compensation function.
T_{lcf}	Load compensation time	
T_{rise}	Load compensation rise slope	
EC	Fine-tuning deviation of CAN communication	
ET	Total deviation	
I_{FEL}	Forced excitation limit of field current	Refer to description of over-excitation limit for more details.
I_{OEL}	Over-excitation limit	
I_E	Actual field current	
T_q	Allowing time of forced excitation	
t	Calculation value of inverse time	
B	Heat accumulation	
B_0	Max allowing heat accumulation	