SmartGen

MAKING CONTROL SMARTER

# HVR410

# DIGITAL VOLTAGE REGULATOR

# USER MANUAL

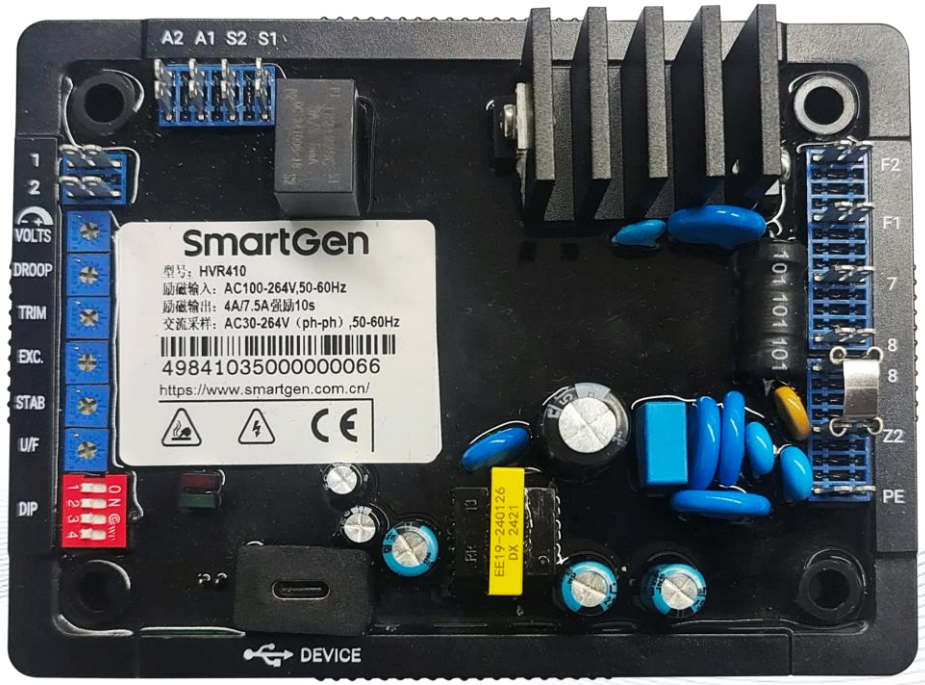


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**Table 1 Software Version**

| Date | Version | Note |
|---|---|---|
| 2025-04-10 | 1.0 | Original Release |
| | | |
| | | |
| | | |

**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

**HVR410 Digital Voltage Regulator** is designed for adjusting the field current of brushless AC synchronous generator, which can be applied to generators with the excitation system of AUXW and SHUNT. The regulation mode of the regulator is automatic voltage regulation (AVR). It has USB interface for operation.

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, while some parameters can be manually adjusted using the on-board potentiometer. It features compact structure, simple connections and high reliability.

## 2 MODEL COMPARISON

**Table 3 Model Comparison**

| Items | | HVR410 | HVR1000 | HVR620 |
|---|---|---|---|---|
| Regulation Mode | AVR Mode | ● | ● | ● |
| | FCR Mode | | ● | |
| | VAR Mode | | ● | |
| | PF Mode | | ● | |
| Generator Voltage Detection | | ● | ● | ● |
| Generator Voltage Detection | | ● | ● | |
| Excitation Power Supply | | AC(100-264)V | 63VDC Excitation System: (100-139)VAC or 125VDC 125VDC Excitation System: (190-277)VAC Single Phase, Three Phase (190-260)VAC or 250VDC | 63VDC Excitation System: (100-139)VAC or 125VDC 125VDC Excitation System: (190-277)VAC or 250VDC |
| 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 | | ● | ● | ● |
| Running Data | | | ● | |
| Alarm Data | | ● | ● | ● |

**NOTE:** The functions of HVR1000, HVR620 controllers mentioned in this document may be changed. For accurate information, please refer to the corresponding user manuals.

## 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;
- The output target value can be adjusted through analog voltage/resistance input;
- Two ways to adjust voltage: potentiometer, parameters configuration on PC;
- 1-way CT, and the rated secondary current of CT is 5A;
- Excitation power supply: voltage input is (100-264) VAC;
- Continuous field current is 4A, maximum short-time current is 7.5A for 10s;
- With load compensation function (LCF);
- Droop function: parallel running generators can automatically allocate reactive load sharing by the droop function;
- Line drop compensation function;
- 1-way of (-10-10)V analog voltage input, 1-way of (0-6000) Ω analogy resistance input;
- Suitable for AC systems of 3P3W, 3P4W, 2P3W and 1P2W at rate frequency between 50Hz/60Hz;
- Detect generation voltage harmonic THDu, generation current THDi, and 1st-15th harmonics;
- Generation voltage/current are measured as true RMS;
- Collect and display excitation voltage, field current, generator voltage, current, frequency, power, etc.;
- Function of heat sink temperature detection and alarm protection;
- Protection and detection function: gen. over/under voltage, gen. over/under frequency, waveform distortion, excitation over voltage, excitation overcurrent, rotating diode fault, etc.;
- Real-time data curve analysis can be done via PC software, which can be used to adjust PID parameters;
- All parameters can be configured on PC via USB interface;
- Rated voltage, droop, excitation protection, stability adjustment and under frequency protection can be adjusted via the on-board potentiometer;
- It can be applied to all types of brushless AC synchronous generators with the excitation system of AUXW and 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 before or after the alarm occurs;
- Modular design, pluggable terminal, screw fixing, compact structure and easy installation.

## 4 SPECIFICATION

**Table 4 Technical Parameters**

| Items | Contents |
|---|---|
| Excitation Power | AC Input:<br>Voltage: (100-264) VAC 1P2W;<br>Frequency: 50Hz/60Hz<br>Residual magnetism voltage > 4VAC (25 Hz) |
| Excitation Output Current | Continuous current: 4A<br>Maximum short-time current: 10s, 7.5A;<br>Coil resistance>15Ω. |
| AC Voltage | Accuracy: 1%, THDu < 5%. |
| AC Sampling Voltage | AC Voltage<br>Range: 30VAC - 264VAC<br>Resolution: 0.1V<br>Accuracy: 0.5% |
| | AC frequency<br>Range: 50Hz/60Hz<br>Resolution: 0.01Hz<br>Accuracy: 0.1Hz |
| | AC Current<br>Rated: 5A<br>Range: 0~15A<br>Resolution: 0.1A<br>Accuracy:0.5% |
| DIP Switch | 4-bit DIP Switch<br>Bit 1~2: Transient response PID selection<br>Bit 3: Generator voltage system selection<br>Bit 4: Generator rated frequency selection |
| Analog Input | Resistance Input<br>Range: 0~6000Ω<br>Resolution: 0.1Ω<br>Accuracy: 1Ω (below 2000Ω)<br>Voltage regulation: max.±10% |
| | Voltage Input<br>Range: -10~10V<br>Resolution: 0.001V<br>Accuracy: 1%<br>Voltage regulation: user-defined |
| Potentiometer | Rated Voltage Regulation Range<br>50VAC –130VAC @ AC110V<br>100VAC –230VAC @ AC220V<br>Droop Control: 0~10% |

| Items | Contents |
|---|---|
| | Trim: 0~10%<br>Over Excitation Protection: 4~12A<br>Stability: 50% - 200% |
| | Under Frequency Protection: 70% - 100%, default as 96%<br>50Hz system, default trip point: 48Hz<br>60Hz system, default trip point: 57Hz |
| USB | Isolated Type-C interface |
| Vibration | (18-2000)Hz: 5g<br>IEC 60068-2-6 |
| Shock | 50$g_n$, 11ms, half-sine, apply three shocks successively in each direction of three mutually perpendicular axes, which means 18 shocks in total.<br>IEC 60068-2-27. |
| Bump | 20g/16ms, half-sine<br>IEC 60255-21-2 |
| Overall Dimension | 144mm x 109mm x 43mm |
| Working Temperature | (-40~+70)°C |
| Working Humidity | (20~95)%RH |
| Storage Temperature | (-40~+85)°C |
| Weight | 0.35kg |
| Installation | Fixed by screws |
| IP Rating | IP20 |

# 5 OPERATION

## 5.1 ILLUSTRATION

### 5.1.1 INDICATORS AND WIRING

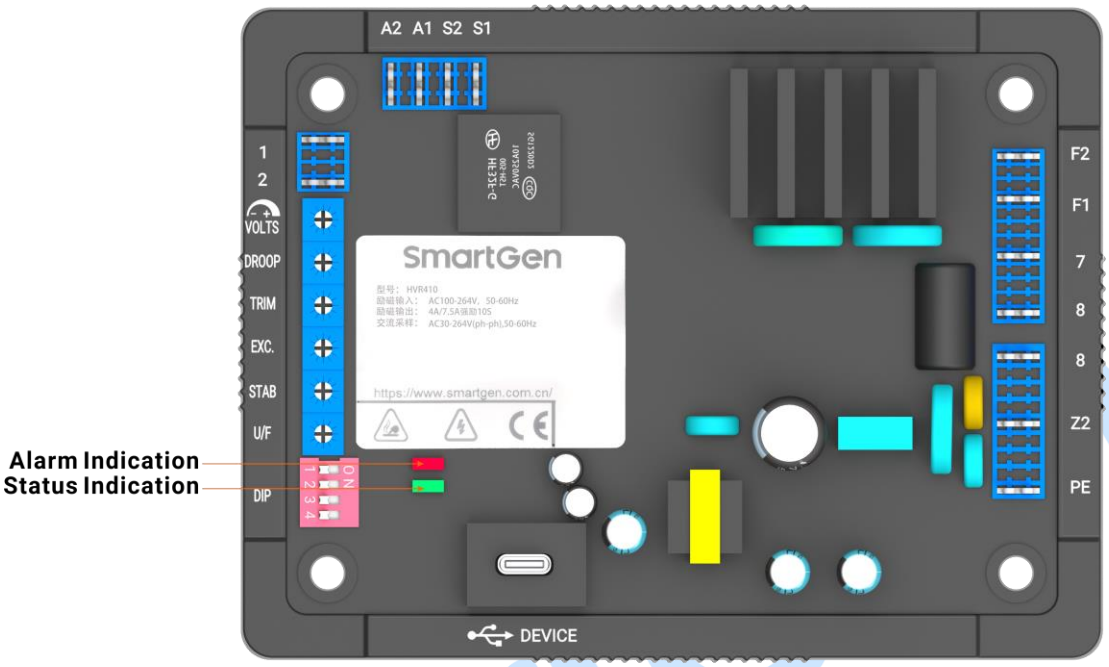



**Fig. 1 Front Indication Diagram**

**Table 5 Indicators Description**

| Type | Function | Description |
|---|---|---|
| Status Indicator (green) | Status | When the generator's current frequency is below the under frequency protection threshold, it flashes slowly (once per second);<br>When the generator's current frequency is equal to or exceeds the under frequency protection threshold, it is always on. |
| Alarm Indicator (red) | Alarm | When AVR fault alarm occurs, it flashes rapidly (5 times per second);<br>When AVR warning alarm occurs, it flashes slowly (once per second);<br>When no AVR alarm occurs, it is off. |

**Table 6 Terminal Wiring Description**

| No. | Function | Cable Size | Remarks |
|---|---|---|---|
| A2 | Voltage-type Analog Input | 1.0mm$^2$ | Voltage-type analog input. |
| A1 | | 1.0mm$^2$ | |
| S2 | Gen Current Input | 1.5mm$^2$ | Externally connected to CT secondary coil (rated 5A). |
| S1 | | 1.5mm$^2$ | |

| No. | Function | Cable Size | Remarks |
|---|---|---|---|
| F2 | Negative Pole | 1.5mm² | Excitation output. |
| F1 | Positive Pole | 1.5mm² | |
| 7 | Common point for excitation power and detection voltage input | 1.5mm² | Used as detection voltage input;<br>Used as excitation power and DVR power supply input. |
| 8 | Detection Voltage Input | 1.5mm² | Used as detection voltage input. |
| 8 | | 1.5mm² | |
| Z2 | Power Supply Voltage Input | 1.5mm² | When using auxiliary winding, connect Terminal 7 and Terminal Z2; when not used, short connect Terminal 8 and Terminal Z2. |
| PE | Protective Earth | 1.5mm² | The grounding line for power system. |
| 1 | Resistance-type analog input | 1.0mm² | Resistance-type analog input. |
| 2 | | 1.0mm² | |
| VOLTS | Rated Voltage Potentiometer | / | Used to adjust the rated voltage (factory default value). |
| DROOP | Droop Potentiometer | / | Used to adjust the droop value (factory default value). |
| TRIM | Trim Potentiometer | / | Used to change the operational range of voltage-type analog input (factory default value). |
| EXC. | Over-excitation Protection Potentiometer | / | Used to adjust the current value of over-excitation protection. |
| STAB | Stability Potentiometer | / | Adjust the current stability based on PID parameters (factory default value). |
| U/F | Under frequency Protection Potentiometer | / | Used to adjust under frequency protection value. |
| DIP Switch | 1 Transient Response Selection | / | Details see Table 7. |
| | 2 Transient Response Selection | / | |
| | 3 Detection Voltage Input Selection | / | |
| | 4 Generator Frequency Selection | / | |
| DEVICE | USB | Isolated | TYPE-C interface for power supply, parameter read/write configuration, real-time monitoring data and program update can be done via PC software. |

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

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

**Table 7 DIP Switch Settings**

| Bit | Function | Description | | | |
|---|---|---|---|---|---|
| 1 | Transient Response | Dip Switch Position | PID Selection | Applicable Power | Response Speed |
| | | 1：OFF<br>2：OFF | PID Parameter 1 | <100KW | Fast |
| | | 1：ON<br>2：OFF | PID Parameter 2 | <100KW | Slow |
| 2 | | 1：OFF<br>2：ON | PID Parameter 3 | 100KW-500KW | Fast |
| | | 1：ON<br>2：ON | PID Parameter 4 | >500KW | Fast |
| 3 | Generator Voltage Selection | OFF：AC220V<br>ON：AC110V | | | |
| 4 | Generator Rated Frequency Selection | OFF：50Hz<br>ON：60Hz | | | |

**NOTE: The DIP switch position is not allowed to be adjusted during generator's running.**

### 5.1.2 EXCITATION OUTPUT

Excitation output provides DC excitation power input for exciter. Excitation output terminals are F1 and F2.

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

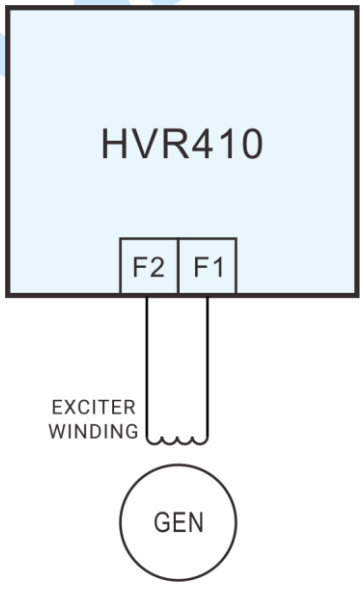



**Fig.2 Excitation Output Wiring Diagram**

### 5.1.3 EXCITATION POWER INPUT AND GENERATOR VOLTAGE DETECTION INPUT

Terminal 7 (COM) and Terminal 8 of DVR constitute the generator voltage detection circuit. The AC voltage input range: 30VAC~264VAC.

Terminal 7 servers as the common reference point for both excitation power supply and voltage detection input. Z2 servers as excitation power input while simultaneously provides operating power to the voltage regulator. When using a SHUNT generator, connect Terminal 8 and Termianl Z2; while using an AUXW generator, connect Terminal 7 and Termianl Z2.

The residual magnetic voltage must exceed 4VAC.

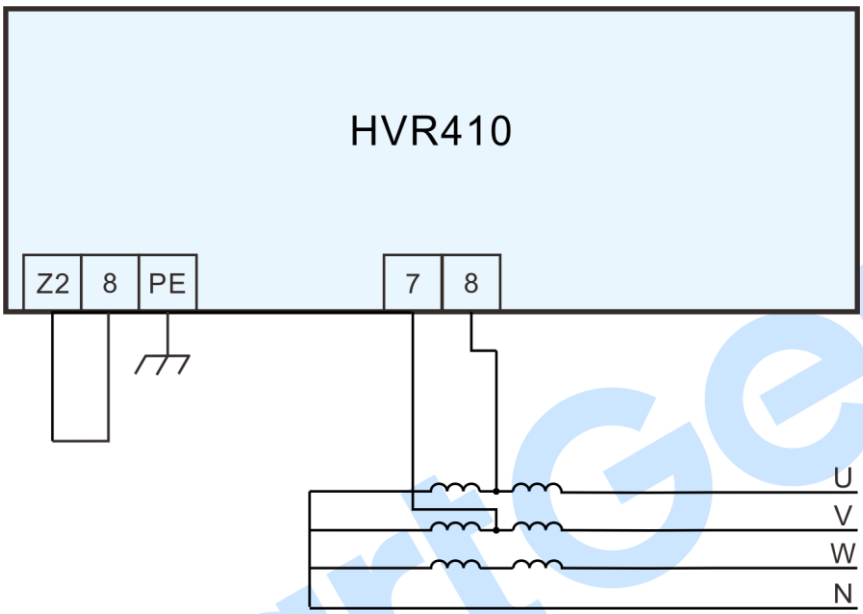



**Fig.3 380/440V Generator Voltage Detection and Excitation Power Input (SHUNT) Wiring Diagram**

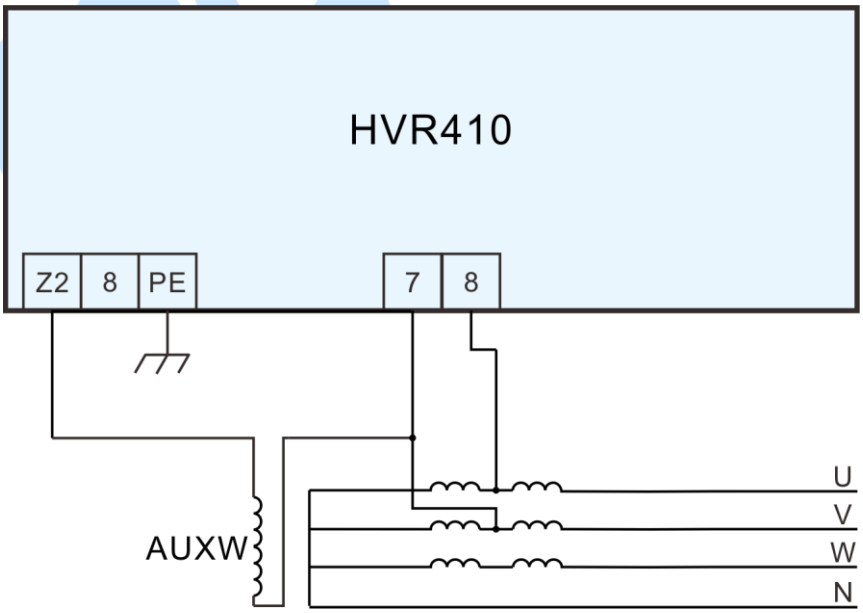



**Fig.4 380/440V Generator Voltage Detection and Excitation Power Input (AUXW) Wiring Diagram**

### 5.1.4 GENERATOR CURRENT DETECTION

The CT secondary rated current is 5A, with RMS range: 0~15A.

The AC voltage sampling lines and current sampling must be on different phases. As show the figure below, the generator voltage detection line are connected to UV two-phase, while the CT should be connected on W-phase.

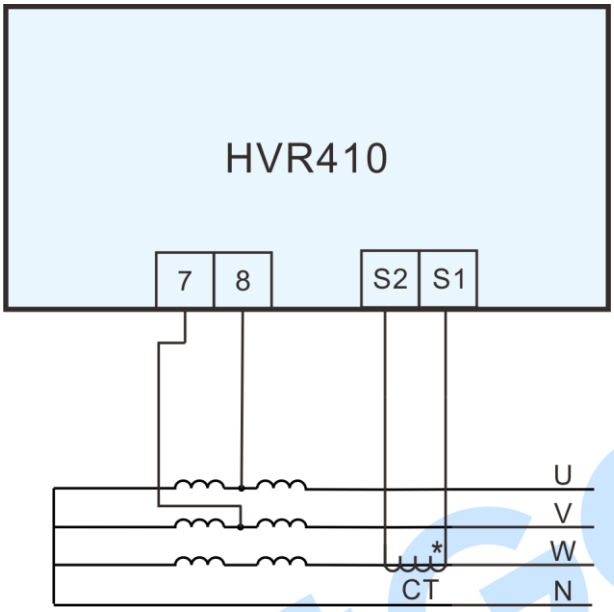



**Fig.5 380/440V Generator Voltage Detection and Generator Current Wiring Diagram**

### 5.1.5 ANALOG INPUT

There are two analog input ports:

Analog Input 1 (voltage type): Terminal A1 and A2, input range is (-10-10)V;

Analog Input 2 (resistance type): Terminal 1 and 2, input range is (0-6000) Ω. The reommend potentiometer range: (2-5) KΩ.

**Both analog inputs are non-isolated.**

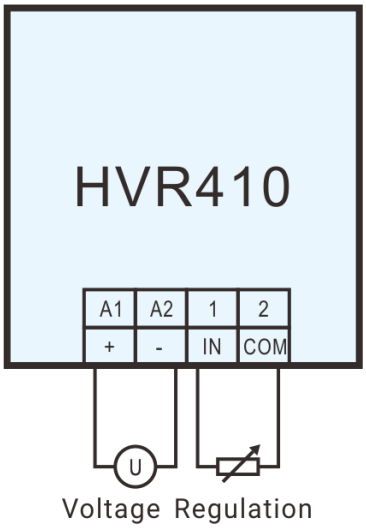



**Fig.6 Analog Input Wiring Diagram**

## 5.2 EXCITATION REGULATION INSTRUCTION

### 5.2.1 SCHEMATIC DIAGRAM

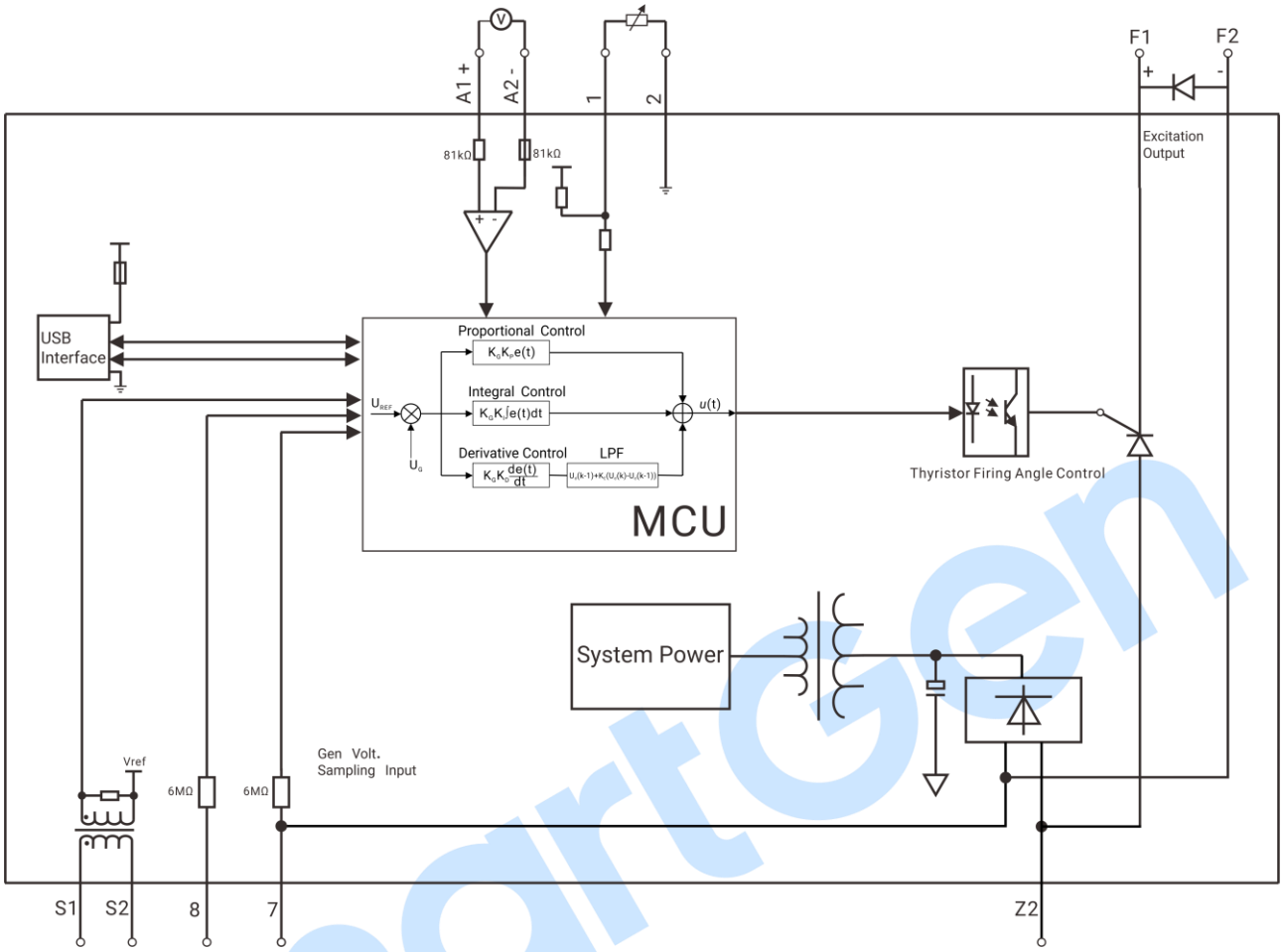



**Fig.7 Schematic Diagram**

### 5.2.2 START

**Soft Start Mode**

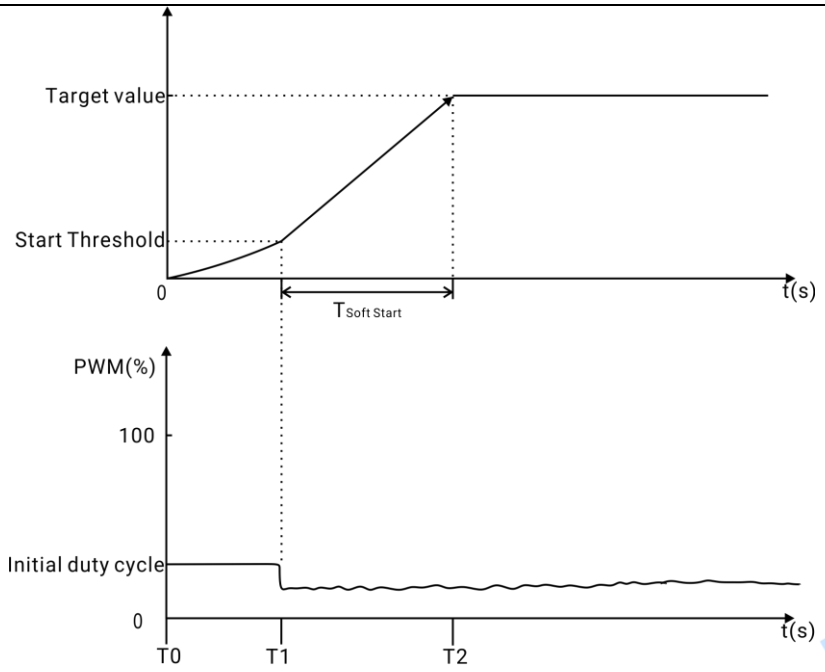
This function can control the change rate of generator voltage, as shown in Figure 8.

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)%(Corresponding Conduction Angle: 0°~180°), default is 40%, 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.



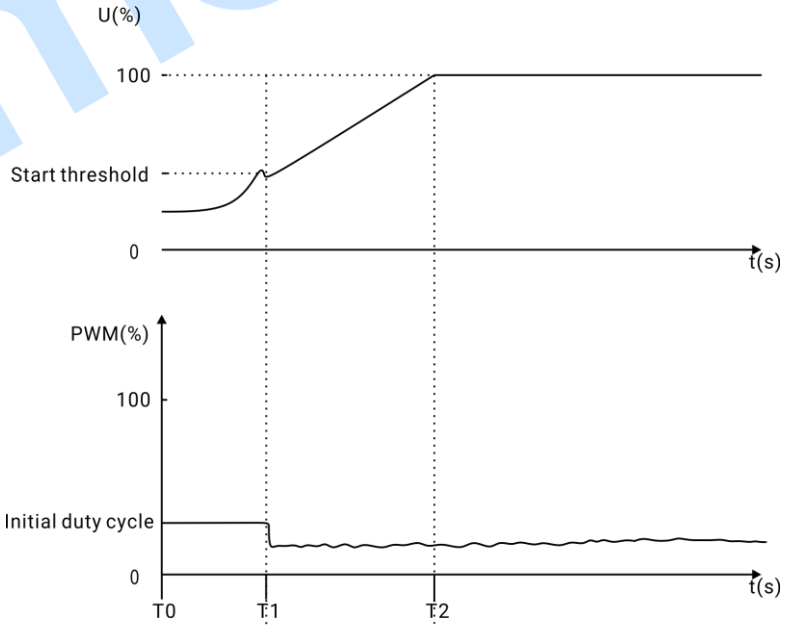

T0-T1: Initial duty cycle of regulator output
T1-T2: Soft start adjusting output (U/F characteristic is still active)

**Fig.8 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.




T0-T1: Initial duty cycle of regulator output
T1-T2: U/F characteristic adjusting output

**Fig.9 Threshold Start Curve Diagram**

### 5.2.3 AUTOMATIC VOLTAGE REGULATION (AVR)

#### 5.2.3.1 ILLUSTRATION OF ADJUSTING RATED VOLTAGE

**1. Potentiometer Mode**

Set the selection of generator voltage adjustment to potentiometer mode on PC software. Configure the voltage regulation range of the onboard rated voltage potentiometer (VOLTS knob) according to the selected voltage system (AC 110V/220V). When using an external voltage regulation potentiometer (VR), set its adjustment range such that the generator's rated output voltage is determined by both the onboard rated voltage potentiometer and external VR (±10% of rated voltage).

Example:

Select 220VAC system via DIP switch, set clockwise limit = 230V, counterclockwise limit = 100V.

Configure external VR resistance limits: 6000Ω (upper) and 0Ω (lower). Place external VR at midpoint or leave unconnected, adjust onboard rated voltage potentiometer to 200V, external VR adjustable range:

$V_{max}$= 200 + (200 * 10%) = 220V

$V_{min}$ = 200 + (200 * -10%) = 180V

**NOTE: The ajustment limits of the external voltage regulation potentiometer (VR) must not exceed the range defined by the rated voltage potentiometer.**

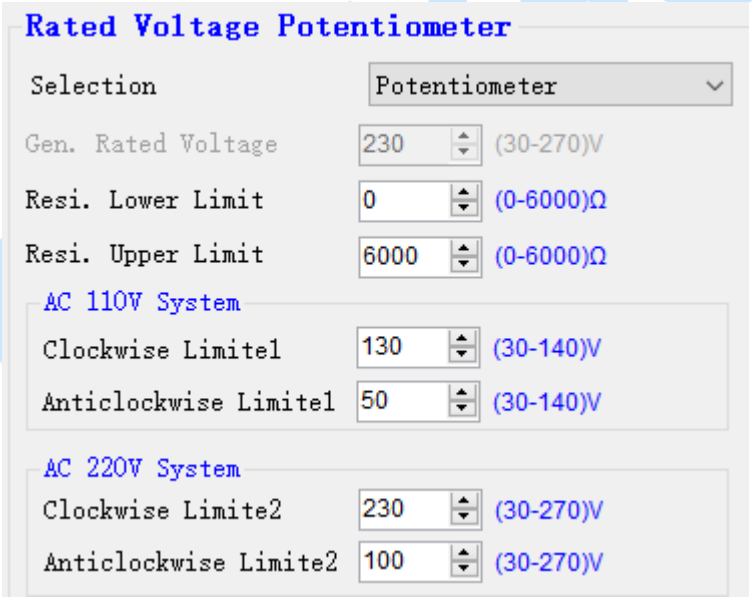



**Fig.10 Rated Voltage Potentiometer Configuration**

**2. Fixed Configuration Value Regulation Mode**

When the PC software selects fixed configuration value for the generator rated voltage, the potentiometer voltage regulation is disabled. The generator's rated voltage will be strictly governed by the preset configuration value.

Example:

On PC software, set the DVR output voltage to 100%, the generator's output voltage target equals the configured value; If set to 90%, the target voltage becomes 90% of the configured value.

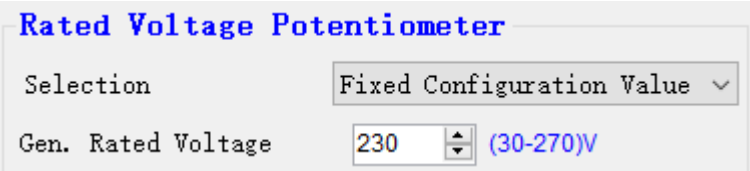



**Fig.11 Fixed Configuration Value of Rated Voltage**

**NOTE 1: The DVR is factory-configured to operate in Potentiometer Mode by default.**

**NOTE 2: Fixed Configuration Value and Potentiometer Mode are mutually exclusive and cannot be active simultaneously. Only one method may be selected.**

#### 5.2.3.2 ILLUSTRATION OF UNDER FREQUENCY PROTECTION THRESHOLD REGULATION

The DVR features under frequency protection function. During the normal operation of generator, if the frequency drops below the under frequency protection threshold, the output voltage will decrease according to the predefined V/Hz slope curve to protect the excitation system.

The under frequency protection characteristics is illustrated in the following figure:

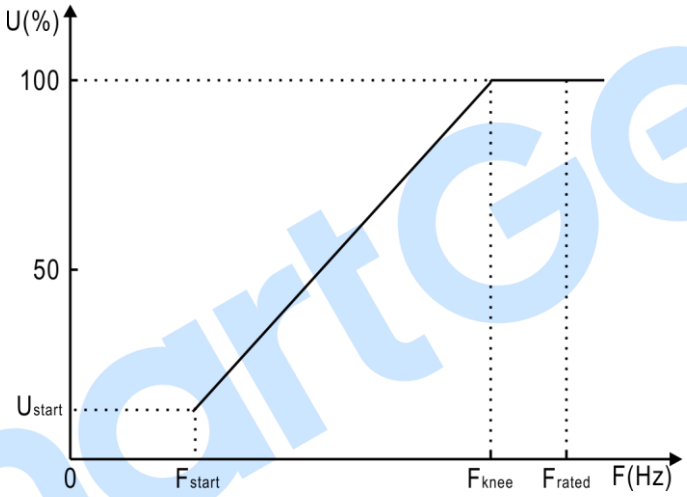



**Fig.12 Under Frequency Protection Feature**

The configuration of under frequency protection threshold includes two modes:

**1. Potentiometer Mode**

On PC software, set under frequency protection option to Potentiometer Mode and configure the counterclockwise limit value to 80%. After the generator starts and achieves voltage buildup, follow these steps: Adjust engine speed to the value corresponding to the target under frequency protection threshold: 48Hz (for 50Hz systems) or 57Hz (for 60Hz systems); Rotate the U/F potentiometer clockwise until the status indicator from illumination to flashing, then rotate the potentiometer counterclockwise until the indicator returns to illumination.

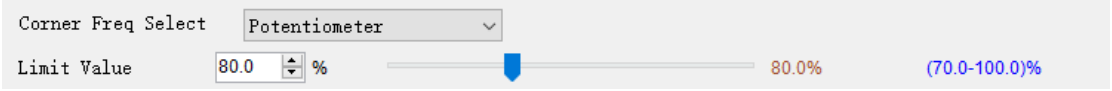



**Fig.13 Under Frequency Potentiometer Configuration**

**2. Fixed Configuration Value Mode**

On PC software, set under frequency protection option to Fixed Configuration Value Mode, set the low knee point frequency ratio to 96%. For a generator with a rated frequency of 50Hz, the under frequency protection knee point is fixed at: $F_{knee}$= 50Hz * 96% = 48Hz.

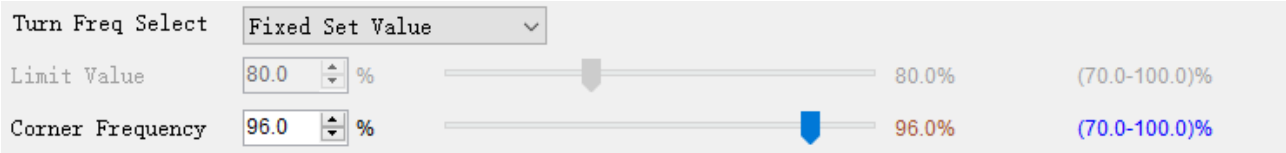



**Fig.14 Fixed Configuration Value of Under Frequency**

**NOTE 1: The DVR is factory-configured to operate in Fixed Configuration Value Mode by default;**

**NOTE 2: Fixed Under Frequency Protection Mode and Potentiometer Mode are mutually exclusive and cannot be active simultaneously. Only one method may be selected.**

### 5.2.3.3 U/F SLOPE CHARACTERISTICS

When the generator frequency falls below the under frequency protection knee point, the DVR supports voltage regulation based on the specified V/Hz slope curve in response to the generator frequency. The configuration of the U/F slope characteristic includes two curve adjustment methods:

**1. Corner frequency curve is set as Not Used**

When Knee Frequency Curves are not used, the generator voltage operates according to the predefined U/F slope curve corresponding to the system frequency.

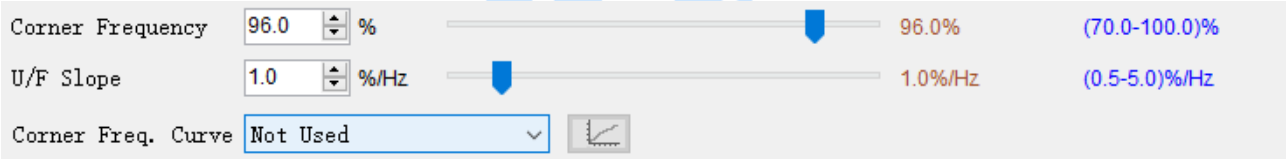



**Fig.15 PC Configuration of Curve**

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. Change the rated frequency by 1Hz, change the rated voltage by SLOPE%. U/F characteristic diagram is shown as below.

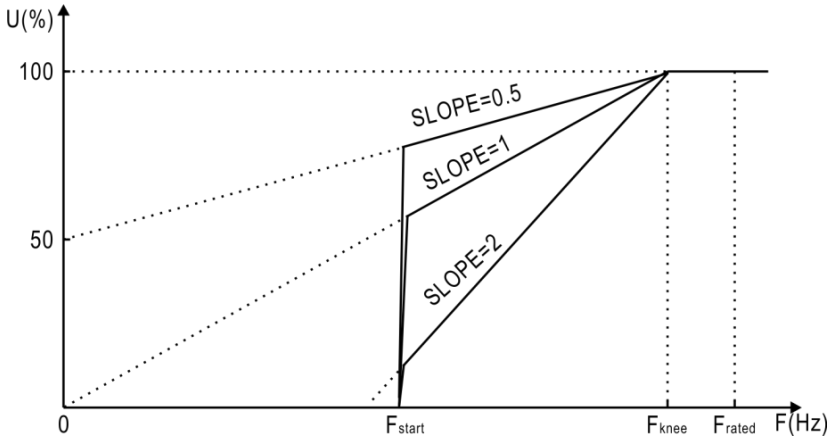



**Fig.16 U/F Characteristic**

**2: Corner frequency curve is set as Custom Curve**

Set the curve as custom curve, and click  to set the U/F Characteristic curve. The voltage change of DVR corresponds to the pre-set frequency curve, and a maximum of 8 coordinate points can be set, as shown in Figure 17.

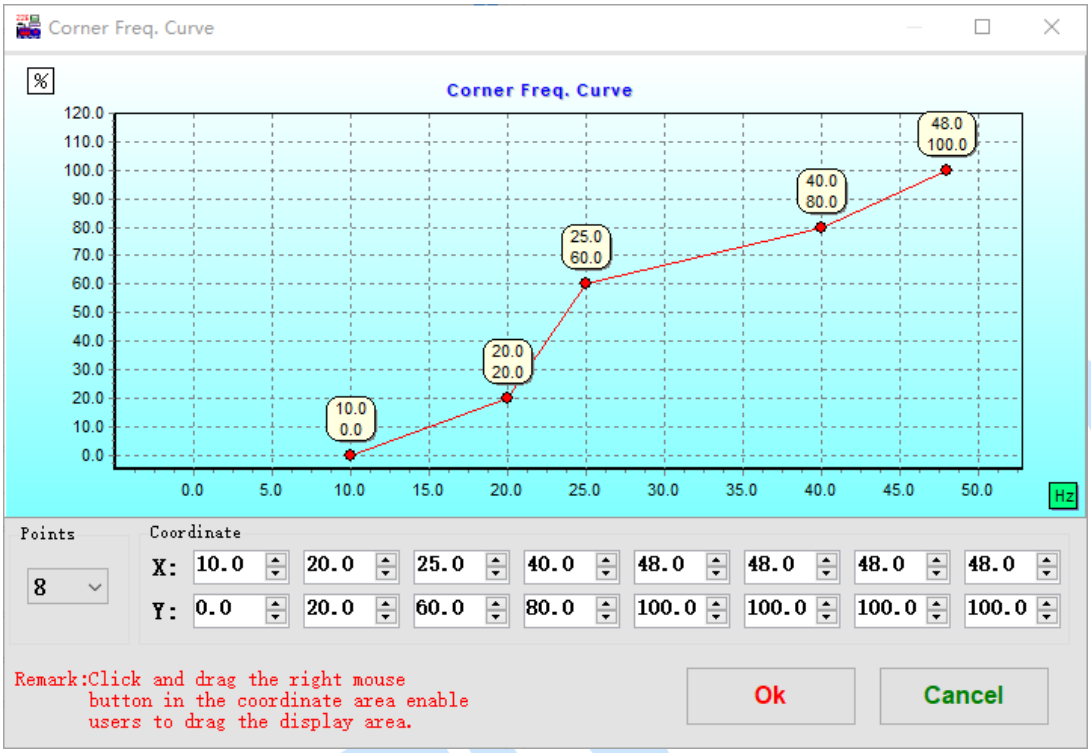



**Fig.17 Corner Frequency Curve Setting**

**NOTE1: Custom knee point curve cannot be used when adjusting the under frequency protection threshold via potentiometer mode.**

### 5.2.3.4 DROOP CONTROL

Parallel-connected generators can achieve automatic reactive load sharing through droop function.

When reactive power is 0%, the target voltage remains unchanged; when reactive power reaches 100%, the target voltage decreases by the configured compensation voltage.

The DVR droop control configuration includes two setting modes:

**1. Potentiometer Mode**

On PC software, set the droop source option to Potentiometer Mode, the configured max. value of external potentiometer corresponds to the droop value when the DROOP potentiometer is adjusted clockwise.

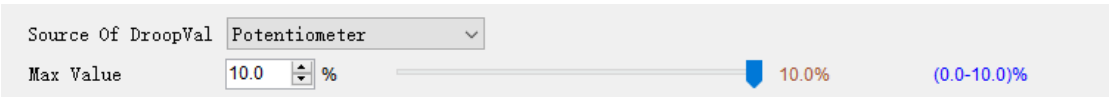



**Fig.18 Droop Potentiometer Setting**

For example:

When the max. value of the external potentiometer is set to 5% and the DROOP potentiometer is rotated fully clockwise (max. position), if the reactive power reaches 100%, the target voltage will be 95% of the rated voltage.

When the max. value of the external potentiometer is set to 5% and the DROOP potentiometer is rotated to the midpoint position, if the reactive power reaches 100%, the target voltage will be 97.5% of the rated voltage.

**2. Fixed Configuration Value Mode**

When droop is configured as a fixed value, the setting range is: 0.1% ~ 10.0% (default: 3.0%).

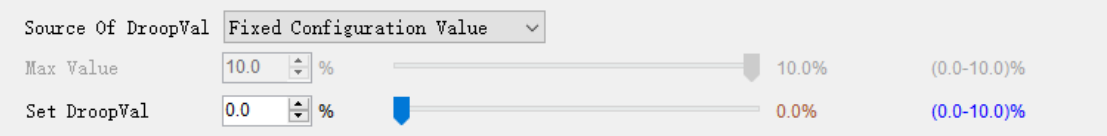



**Fig.19 Droop Fixed Configuration Value Setting**

For example:

Set the fixed droop value to 5%, reactive power to 0%, the target voltage equals the rated voltage; When reactive power reaches 100%, the target voltage becomes 95% of the rated voltage.

The droop control voltage curve is shown as below:

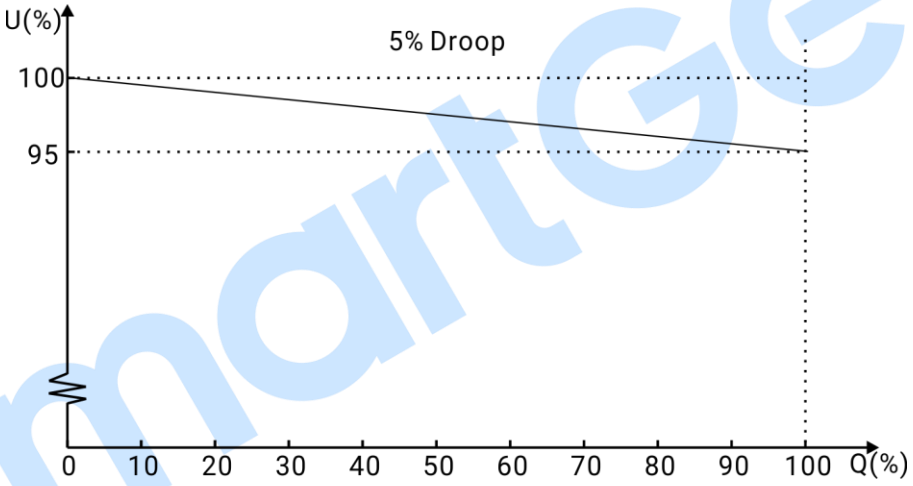



**Fig.20 Droop Control Voltage Curve**

**⚠NOTE 1: The DVR is factory-configured to operate in Fixed Configuration Value Mode by default;**

**⚠NOTE 2: Fixed Droop Configuration Value Mode and Potentiometer Mode are mutually exclusive and cannot be active simultaneously. Only one method may be selected.**

### 5.2.3.5 TRANSMISSION LINE DROP COMPENSATION

The compensation range of transmission line voltage drop is 0.0% to 20.0% ( default: 3.0%).

When the apparent power is 0%, the target voltage remains unchanged; When the apparent power reaches 100%, the target voltage increases to the predefined compensation voltage.

This function compensates for occasions where long transmission cables or increased load currents cause significant voltage drops.

For example:

Set the transmission line voltage drop compensation to 5%, under rated voltage conditions:

When the apparent power is 0% , the target voltage remains unchanged;When the apparent power reaches 100% , the target voltage increases to 105% of the rated voltage.

The compensation curve of transmission line voltage drop is shown as below:

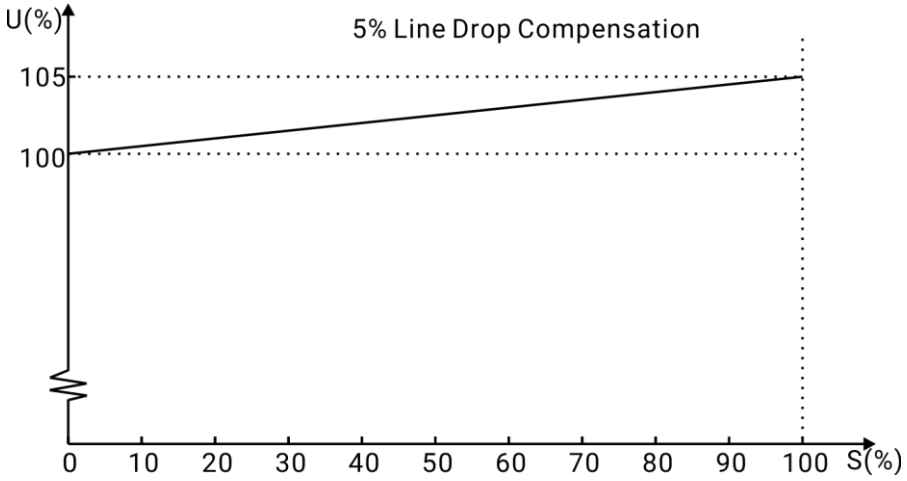



**Fig.21 Transmission Line Voltage Drop Curve**

#### 5.2.3.6 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 ($T_{rise}$): (0.0~10.0)%/s, default is 0.2%/s.

When gen frequency drops to knee frequency ($F_{knee}$), target voltage rapidly 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.

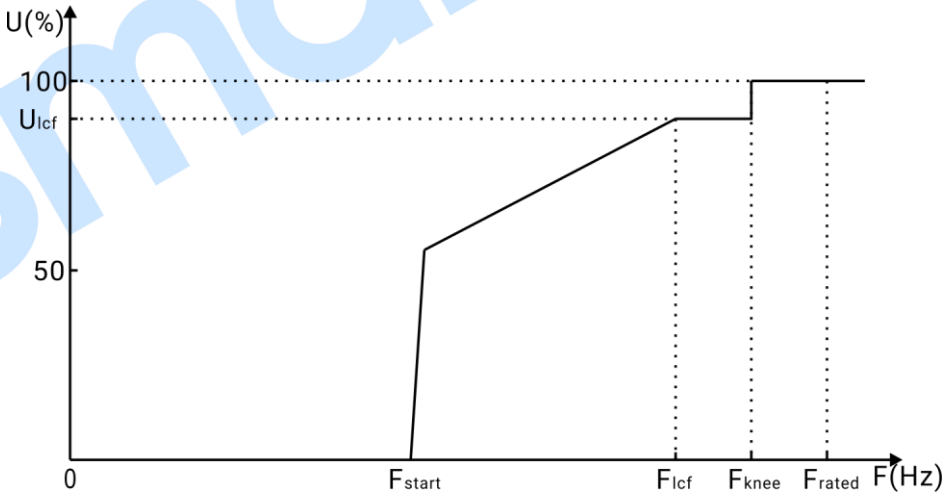
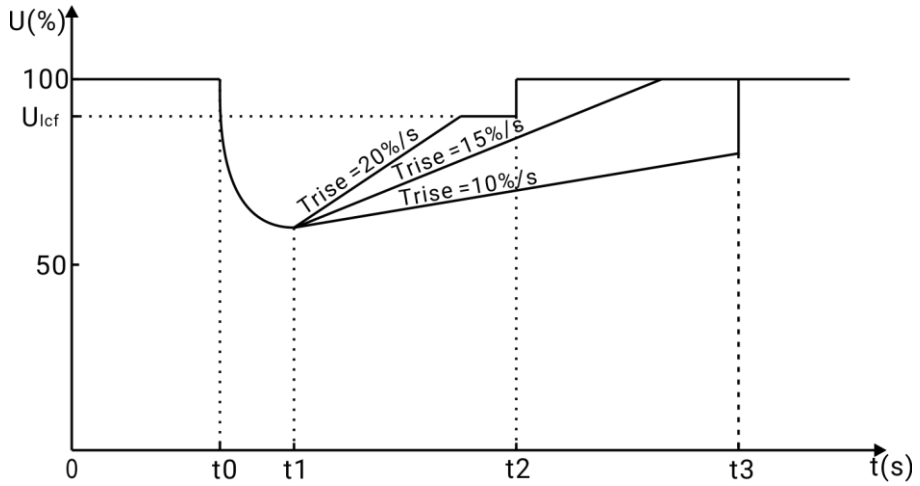



**Fig.22 U/F Curve During Load Compensation**




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.23 Voltage/Time Curve During Load Compensation**

### 5.2.3.7 AUXILIARY INPUT REGULATION

Auxiliary Inputs (A1, A2) can be connected to power factor correction (PFC) devices, with an input voltage range of ±10V.

The adjustment range configuration for auxiliary inputs includes two modes:

**1. Potentiometer Mode**

When the voltage trim function is set to Potentiometer Mode, the TRIM potentiometer knob is used to adjust the range of auxiliary inputs. Rotating the knob counterclockwise will reduce the analog voltage's range; while rotating the knob clockwise will increase the analog voltage's range.


**Fig.24 Auxiliary Input Potentiometer Configuration**

For example:

Set the clockwise adjustment range to 10% and the TRIM potentiometer is rotated fully clockwise (max. position), the auxiliary input voltage is 1.0V.

The voltage trim deviation: EV = -10%+ (10% - -10%)*1.0/(5.0-0) = -6.0%

The target voltage becomes 94% of the current rated voltage.

**2. Fixed Configuration Value Mode**

On PC software, set the voltage trim to a fixed configuration value, the max. adjustable range of the power factor remains constant value.

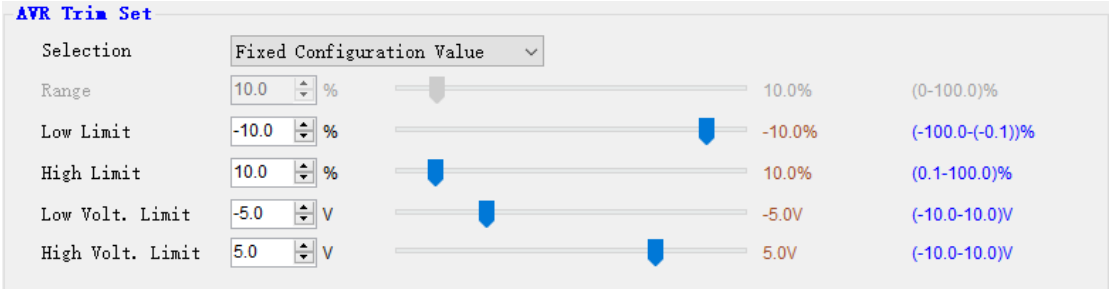



**Fig.25 Auxiliary Input Fixed Configuration**

**NOTE 1: The DVR is factory-configured to operate in Potentiometer Mode by default;**

**NOTE 2: The Fixed Configuration Value Mode and Potentiometer Mode are mutually exclusive and cannot be active simultaneously. Only one method may be selected.**

### 5.2.3.8 STABILITY REGULATION

Different PID parameters for regulation based on motor parameters and load conditions. By configuring the OFF/ON states of Positions 1 and 2 on DIP switch, users can select any one of 4 types of PID parameters.

Set the PID stability option to Potentiometer Mode, the selected PID parameters can be manually adjusted within a range of 50% to 200% by rotating the potentiometer (STAB). Excessive stability gain may cause voltage instability; while insufficient stability gain may result in significant transient voltage fluctuations during abrupt load changes.

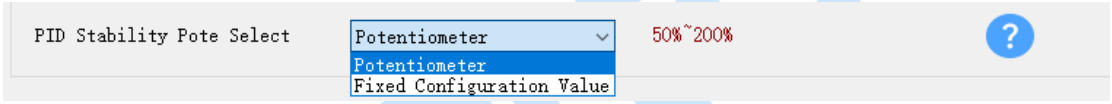



**Fig.26 Stability Regulation Configuration**

**NOTE 1: The DVR is factory-configured to operate in Potentiometer Mode by default;**

**NOTE 2: The Fixed Configuration Value Mode and Potentiometer Mode are mutually exclusive and cannot be active simultaneously. Only one method may be selected.**

### 5.2.3.9 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 8 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.<br>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.<br>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.<br>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.<br>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, it will send warning alarm signal.<br>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.<br>It is always detected. |
| 7 | 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.<br>It is always detected. |
| 8 | 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.<br>It is always detected. |
| 9 | Low Power Factor | When low power factor detection is enabled and regulator detects that gen power factor is less than the pre-set alarm threshold, it will send warning alarm signal.<br>It is detected when current power exceeds 10% of the rated power. |
| 10 | Over Power | When over power alarm detection is enabled and regulator detects that generator power is over than the pre-set threshold, it will send warning alarm signal.<br>It is always detected. |

| No. | Warning | Description |
|---|---|---|
| 11 | Reverse Power | When reverse power alarm detection is enabled and regulator detects that generator reverse power (negative power) is over than the pre-set threshold, it will send warning alarm signal.<br>It is always detected. |
| 12 | Loss of Excitation | When the loss of excitation alarm detection is enabled and regulator detects that the generator reactive power (negative power) is over than the pre-set threshold, it will send warning alarm signal.<br>It is always detected. |
| 13 | Large THDi | When current waveform distortion detection is enabled and regulator detects that load waveform distortion is over than the pre-set threshold, it will send warning alarm signal.<br>It is always detected. |
| 14 | Short Circuit | When short circuit detection is enabled and regulator detects that load current is over than the pre-set threshold, it will send warning alarm signal.<br>It is always detected. |
| 15 | Rotating Diode Short Circuit | When rotating diode short circuit detection is enabled and regulator detects that current waveform distortion is higher than threshold, it will send warning alarm signal.<br>It is always detected. |
| 16 | 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 95°C), regulator will send warning alarm signal.<br>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 6 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 9 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.<br>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.<br>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. |

| No. | Fault | Description |
|---|---|---|
| | | 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.<br>It is detected after gen frequency is higher than knee frequency firstly. |
| 5 | Excitation Over Current | When over-excitation limit is enabled, over-excitation limit is active and action is shutdown, it will send fault alarm signal.<br>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 fault alarm signal.<br>It is always detected. |
| 7 | Large THDu | When voltage waveform distortion detection is enabled and regulator detects that THDu is higher than threshold, it will send fault alarm signal.<br>It is always detected. |
| 8 | Over Power | When over power alarm detection is enabled and regulator detects that load power (positive power) is over than the pre-set threshold, it will send fault alarm signal.<br>It is always detected. |
| 9 | Reverse Power | When reverse power alarm detection is enabled and regulator detects that load reverse power (negative power) is over than the pre-set threshold, it will send warning alarm signal.<br>It is always detected. |
| 10 | Low Power Factor | When low power factor detection is enabled and regulator detects that gen power factor is less than the pre-set alarm threshold, it will send fault alarm signal.<br>It is detected when current power exceeds 10% of the rated power. |
| 11 | Large THDi | When current waveform distortion detection is enabled and regulator detects that current harmonic is over than the pre-set threshold, it will send fault alarm signal.<br>It is always detected. |
| 12 | Short Circuit | When short circuit detection is enabled and regulator detects that load current is over than the pre-set threshold, it will send fault alarm signal.<br>It is always detected. |
| 13 | Loss of Excitation | When the loss of excitation alarm detection is enabled and regulator detects that the generator reactive power (negative power) is over than the pre-set threshold, it will send fault alarm signal.<br>It is always detected. |
| 14 | Rotating Diode Open | When rotating diode open circuit detection is enabled and regulator detects that current waveform distortion is higher than threshold, it will send fault alarm signal.<br>It is always detected. |
| 15 | Rotating Diode Short Circuit | When rotating diode short circuit detection is enabled and regulator detects that current waveform distortion is higher than threshold, it will send fault alarm signal. |

| No. | Fault | Description |
|---|---|---|
| | | It is always detected. |
| 16 | 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 95°C), regulator will send fault alarm signal.<br>It is always detected. |

## 6.3 OVER EXCITATION LIMIT

The excitation current should be always detected during generator operation. The over excitation may damage the DVR or generator filed windings. There are two protection modes for over excitation limit function:

**1.Potentiometer Mode**

The DVR uses an over excitation protection potentiometer (EXC.) to adjust its threshold. By rotating the knob, the protection value can be set within 100% to 300% of the rated field current. If the generator operates over than this threshold for 10s, an “Excitation Overcurrent Fault” alarm will be triggered. In this case, the generator must be shut down and restarted to restore normal running.

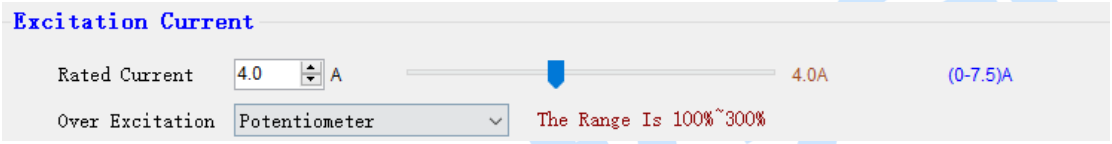



**Fig.27 Configuration of Excitation Overcurrent Protection Potentiometer**

**2.Fixed Configuration Value Mode**

When the generator operates in the over-excitation range of its power characteristic curve, it can cause overheating of the excitation winding. Therefore, the generator must restore the system voltage by supplying additional reactive power to the system, i.e., utilizing its forced excitation capability. The over-excitation limit can be configured with two excitation overcurrent thresholds: Excitation Overcurrent 2 Threshold serves as the forced excitation limit; Excitation Overcurrent 1 Threshold serves as the long-term permissible excitation current. The regulator implements instantaneous limitation on the excitation current during forced excitation. When the forced excitation limit is active, the excitation current is restricted to below 0.95 times the Excitation Overcurrent 2 Threshold; If the excitation current exceeds the Overcurrent 1 Threshold and the over excitation inverse-time delay is reached, the excitation current over excitation limit activates, restricting the current to below 0.95 times the Excitation Overcurrent 1 Threshold while waiting for accumulated heat to dissipate.

The action upon activation of over-excitation limit can be configured. Once the over excitation limit takes effect, the regulator will issue a warning or fault alarm after the preset over excitation limit action delay 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: $B = B+(I_E^2-I_{OEL}^2)\triangle t$;
3) B>0, $I_E > I_{OEL}$, over-excitation never occurred, current over-excitation, heat accumulation: $B = B+(I_E^2-I_{OEL}^2)\triangle t$;
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: $B = B+(I_E^2-I_{OEL}^2)\triangle t$, 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.28 Over-excitation Limit Configuration on PC Software**

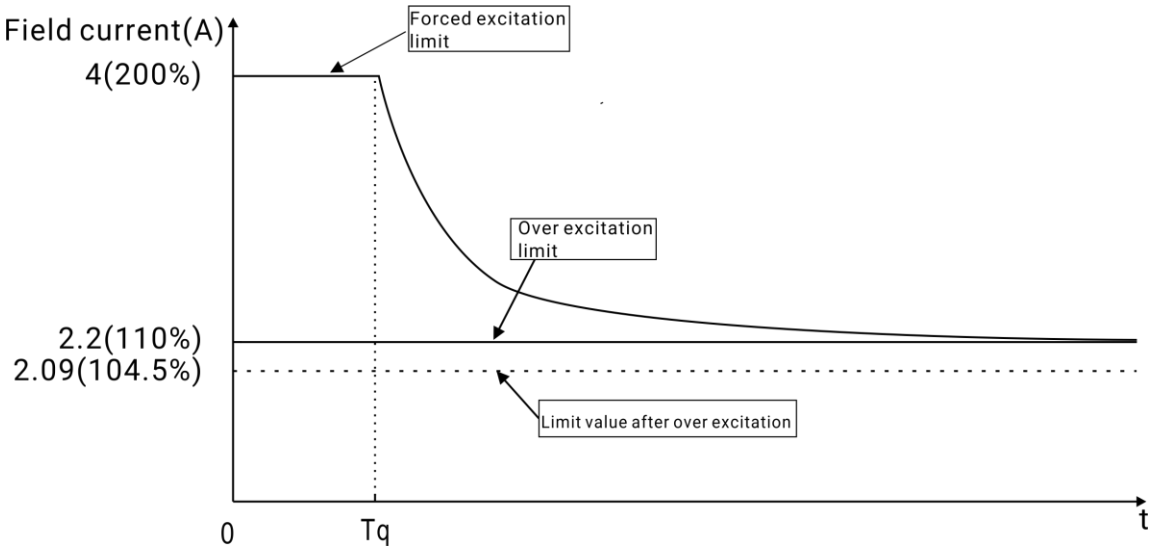



**Fig.29 Over-excitation Limit Setting**

**NOTE 1: The DVR is factory-configured to operate in Fixed Configuration Mode by default;**

**NOTE 2: The Fixed Configuration Value Mode and Potentiometer Mode are mutually exclusive and cannot be active simultaneously. Only one method may be selected.**

## 7 CONFIGURABLE PARAMETERS RANGE AND DEFINITION

**Table 10 Parameters Setting and Range**

| No. | Item | Range | Default | Description |
|---|---|---|---|---|
| Module Setting | | | | |
| 1 | Password Setting | (0-9999) | 0318 | |
| 2 | Alarm Data Record Interval | (0-60.0) s | 0.1 | |
| System Setting | | | | |
| 1 | Rated Voltage Potentiometer Option | (0-1) | 0 | 0: Potentiometer<br>1: Fixed Set Value |
| 2 | Gen Rated Voltage | (30-270) V | 230 | Standard for gen over/under voltage, gen target voltage. |
| 3 | Counterclockwise Limit | (30-140)V | 50 | Apply for 110VAC system. |
| 4 | Clockwise Limit | (30-140)V | 130 | |
| 5 | Counterclockwise Limit | (30-270) V | 100 | Apply for 220VAC system. |
| 6 | Clockwise Limit | (30-270) V | 230 | |
| 7 | Gen Rated Frequency Option | (0-1) | 0 | 0: DIP Switch<br>1: Fixed Set Value |
| 8 | Gen Rated Frequency | (10.0-100.0)Hz | 50.0 | |
| 9 | Gen Rated Current | (5-6000)A | 500 | |
| 10 | Gen Rated Active Power | (0-6000)kW | 276 | |
| 11 | Gen Rated Reactive Power | (0-6000)kvar | 208 | |
| 12 | Gen Rated Apparent Power | (0-6000)kVA | 346 | |
| 13 | Gen Rated Power Factor | (0.00-1.00) | 0.8 | |
| 14 | Generator Poles | (1-64) | 4 | Poles ratio = exciter poles/gen |

| No. | Item | | | Range | Default | Description |
|---|---|---|---|---|---|---|
| 15 | Exciter Poles | | | (0-64) | 0 | poles; It is for rotating diode fault detection. |
| 16 | CT Setting | | | (0-1) | 0 | 0: Disable<br>1: Enable |
| 17 | CT Primary Current | | | (5-6000)A | 500 | |
| 18 | Power Coefficient | | | (1.0-10.0) | 2.0 | Power calculation coefficient. |
| 19 | Lower Limit Resistance Value | | | (0-6000)Ω | 0 | Acts together with the voltage potentiometer to regulate the rated voltage. |
| 20 | Upper Limit Resistance Value | | | (0-6000)Ω | 6000 | |
| Excitation Setting | | | | | | |
| 1 | Over-excitation Setting Value Enable | | | (0-1) | 1 | 0: DIP Switch<br>1: Fixed Set Value |
| 2 | Rated Voltage | | | (0-125) V | 63 | Rated excitation voltage, standard for excitation over/under voltage. |
| 3 | Over Voltage 1 Setting | | | (0-1) | 1 | 0: Disable; 1: Enable.<br>Set value is the percentage of rated excitation voltage.<br>Return value is the percentage of rated excitation voltage<br>Delay value.<br>Action:<br>0: None; 1: Warning; 2: Fault. |
| | | | | (0-200.0) % | 120 | |
| | | | | (0-200.0) % | 116 | |
| | | | | (0-3600) s | 3 | |
| | | | | (0-2) | 2 | |
| 4 | Over Voltage 2 Setting | | | (0-1) | 1 | |
| | | | | (0-200.0) % | 110 | |
| | | | | (0-200.0) % | 108 | |
| | | | | (0-3600) s | 5 | |
| | | | | (0-2) | 1 | |
| 5 | Rated Current | | | (0-7.5) A | 4.0 | Rated field current, standard for over-excitation limit. |
| 6 | Over Excitation Limit (OEL) | 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 | Act | (0-2) | 1 | Action:<br>0: None; 1: Warning; 2: Fault. |
| | | | Delay | (0-3600) s | 10 | Delay value. |
| 7 | Short Circuit Setting of Rotating Diode | | | (0-1) | 0 | 0: Disable; 1: Enable.<br>Set value is the percentage of field current harmonic.<br>Return value is the percentage of field current harmonic.<br>Delay value.<br>Action:<br>0: None; 1: Warning; 2: Fault. |
| | | | | (0-100.0) % | 10 | |
| | | | | (0-100.0) % | 9 | |
| | | | | (0-3600) s | 1 | |
| | | | | (0-2) | 2 | |
| 8 | Open Circuit Setting of Rotating Diode | | | (0-1) | 0 | |
| | | | | (0-100.0) % | 5 | |
| | | | | (0-100.0) % | 4 | |
| | | | | (0-3600) s | 5 | |

| No. | Item | Range | Default | Description |
|---|---|---|---|---|
| | | (0-2) | 2 | |
| 9 | Heat sink Temp. Protection Setting | (0-1) | 1 | 0: Disable; 1: Enable. |
| | | (-40-120)°C | 95 | Set value |
| | | (-40-120)°C | 90 | Return value |
| | | (0-3600)s | 5 | Delay value |
| | | (0-2) | 2 | Action:<br>0: None; 1: Warning; 2: Fault.<br>3: Lower voltage. |
| Generator Setting | | | | |
| 1 | Gen Over Voltage Alarm 1 | (0-1) | 1 | 0: Disable; 1: Enable.<br>Set value is the percentage of gen rated voltage.<br>Return value is the percentage of gen rated voltage.<br>Delay value.<br>Action:<br>0: None; 1: Warning; 2: Fault. |
| | | (0-200.0) % | 120 | |
| | | (0-200.0) % | 118 | |
| | | (0-3600) s | 3 | |
| | | (0-2) | 2 | |
| 2 | Gen Over Voltage Alarm 2 | (0-1) | 1 | |
| | | (0-200.0) % | 110 | |
| | | (0-200.0) % | 108 | |
| | | (0-3600) s | 5 | |
| | | (0-2) | 1 | |
| 3 | Gen Under Voltage Alarm 1 | (0-1) | 1 | |
| | | (0-200.0) % | 80 | |
| | | (0-200.0) % | 82 | |
| | | (0-3600) s | 3 | |
| | | (0-2) | 2 | |
| 4 | Gen Under Voltage Alarm 2 | (0-1) | 1 | |
| | | (0-200.0)% | 84 | |
| | | (0-200.0)% | 86 | |
| | | (0-3600)s | 5 | |
| | | (0-2) | 1 | |
| 5 | Gen Over Frequency Alarm 1 | (0-1) | 1 | 0: Disable; 1: Enable<br>Set value is the percentage of gen rated frequency.<br>Return value is the percentage of gen rated frequency.<br>Delay value.<br>Action:<br>0: None; 1: Warning; 2: Fault. |
| | | (0-200.0%) | 114 | |
| | | (0-200.0%) | 110 | |
| | | (0-3600s) | 3 | |
| | | (0-2) | 2 | |
| 6 | Gen Over Frequency Alarm 2 | (0-1) | 1 | |
| | | (0-200.0) % | 110 | |
| | | (0-200.0) % | 108 | |
| | | (0-3600) s | 5 | |
| | | (0-2) | 1 | |
| 7 | Gen Under Frequency Alarm 1 | (0-1) | 0 | |
| | | (0-200.0) % | 80 | |
| | | (0-200.0) % | 82 | |

| No. | Item | Range | Default | Description |
|---|---|---|---|---|
| | | (0-3600) s | 3 | |
| | | (0-2) | 2 | |
| 8 | Gen Under Frequency Alarm 2 | (0-1) | 0 | |
| | | (0-200.0) % | 84 | |
| | | (0-200.0) % | 86 | |
| | | (0-3600) s | 5 | |
| | | (0-2) | 1 | |
| 9 | Gen Waveform Distortion 1 | (0-1) | 0 | 0: Disable; 1: Enable<br>Set value is percentage of gen unbalanced voltage.<br>Return value is percentage of gen unbalanced voltage.<br>Delay value.<br>Action:<br>0: None; 1: Warning; 2: Fault. |
| | | (0-200.0%) | 10 | |
| | | (0-200.0%) | 5 | |
| | | (0-3600s) | 5 | |
| | | (0-2) | 0 | |
| 10 | Gen Waveform Distortion 2 | (0-1) | 0 | |
| | | (0-200.0%) | 10 | |
| | | (0-200.0%) | 5 | |
| | | (0-3600s) | 5 | |
| | | (0-2) | 0 | |
| 11 | Current Waveform Distortion 1 | (0-1) | 0 | 0: Disable; 1: Enable<br>Set value is waveform distortion degree of gen voltage.<br>Return value is waveform distortion degree of gen voltage.<br>Delay value.<br>Action: 0: None; 1: Warning; 2: Fault. |
| | | (0-200.0%) | 10 | |
| | | (0-200.0%) | 5 | |
| | | (0-3600s) | 5 | |
| | | (0-2) | 0 | |
| 12 | Current Waveform Distortion 2 | (0-1) | 0 | |
| | | (0-200.0%) | 10 | |
| | | (0-200.0%) | 5 | |
| | | (0-3600s) | 5 | |
| | | (0-2) | 0 | |
| 13 | Short Circuit Alarm 1 | (0-1) | 1 | 0: Disable 1: Enable |
| | | (0-300.0)% | 200 | |
| | | (0-300.0)% | 180 | |
| | | (0-3600)s | 1 | Delay value. |
| | | (0-2) | 2 | Action:<br>0: None; 1: Warning; 2: Fault. |
| 14 | Short Circuit Alarm 2 | (0-1) | 0 | 0: Disable 1: Enable |
| | | (0-300.0)% | 200 | |
| | | (0-300.0)% | 180 | |
| | | (0-3600)s | 5 | Delay value. |
| | | (0-2) | 1 | Action:<br>0: None; 1: Warning; 2: Fault. |
| 15 | Over Power Alarm 1 | (0-1) | 1 | 0: Disable 1: Enable |

| No. | Item | Range | Default | Description |
|---|---|---|---|---|
| | | (0-200.0)% | 120 | |
| | | (0-200.0)% | 118 | |
| | | (0-3600)s | 3 | Delay value. |
| | | (0-2) | 2 | Action:<br>0: None; 1: Warning; 2: Fault. |
| 16 | Over Power Alarm 2 | (0-1) | 0 | 0: Disable 1: Enable |
| | | (0-200.0)% | 110 | |
| | | (0-200.0)% | 118 | |
| | | (0-3600)s | 5 | Delay value. |
| | | (0-2) | 1 | Action:<br>0: None; 1: Warning; 2: Fault. |
| 17 | Reverse Power Alarm 1 | (0-1) | 1 | 0: Disable 1: Enable |
| | | (0-200.0)% | 10.0 | |
| | | (0-200.0)% | 8.0 | |
| | | (0-3600)s | 3 | Delay value. |
| | | (0-2) | 2 | Action:<br>0: None; 1: Warning; 2: Fault. |
| 18 | Reverse Power Alarm 2 | (0-1) | 0 | 0: Disable 1: Enable |
| | | (0-200.0)% | 5.0 | |
| | | (0-200.0)% | 3.0 | |
| | | (0-3600)s | 5 | Delay value. |
| | | (0-2) | 1 | Action:<br>0: None; 1: Warning; 2: Fault. |
| 19 | Loss of Excitation Fault 1 | (0-1) | 1 | 0: Disable 1: Enable |
| | | (0-200.0)% | 20 | |
| | | (0-200.0)% | 18 | |
| | | (0-3600)s | 5 | Delay value. |
| | | (0-2) | 1 | Action:<br>0: None; 1: Warning; 2: Fault. |
| 20 | Loss of Excitation Fault 2 | (0-1) | 0 | 0: Disable 1: Enable |
| | | (0-200.0)% | 20 | |
| | | (0-200.0)% | 18 | |
| | | (0-3600)s | 5 | Delay value. |
| | | (0-2) | 1 | Action:<br>0: None; 1: Warning; 2: Fault. |
| 21 | Low Power Factor 1 | (0-1) | 1 | 0: Disable 1: Enable |
| | | (0-1.0)% | 0.70 | |
| | | (0-1.0)% | 0.75 | |
| | | (0-3600)s | 5 | Delay value. |
| | | (0-2) | 2 | Action:<br>0: None; 1: Warning; 2: Fault. |

| No. | Item | | Range | Default | Description |
|---|---|---|---|---|---|
| 22 | Low Power Factor 2 | | (0-1) | 0 | 0: Disable 1: Enable |
| | | | (0-1.0)% | 0.70 | |
| | | | (0-1.0)% | 0.75 | |
| | | | (0-3600)s | 5 | Delay value. |
| | | | (0-2) | 1 | Action:<br>0: None; 1: Warning; 2: Fault. |
| AVR Setting | | | | | |
| 1 | AVR Output Voltage | | (0.0-200.0) % | 100.0 | Output voltage value in AVR mode, which is the percentage of rated voltage. |
| 2 | Soft-start Enable | | (0-1) | 0 | 0: Disable; 1: Enable. |
| 3 | Soft-start Time | | (0.1-120)s | 3 | When the soft-start function is enabled, time for the generator voltage to rise from the soft-start initial voltage to the rated voltage." |
| 4 | Volt/Freq. (U/F) Set | Start Freq. | (10.0-100.0) % | 20 | Gen frequency when U/F characteristic starts. |
| | | Knee Freq. Option | (0-1) | 1 | 0: Potentiometer<br>1: Fixed Set Value |
| | | Counterclockwise Limit | (70.0-100.0)% | 80 | |
| | | 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, change the current Gen frequency by 1Hz, change the target voltage by SLOPE% |
| 5 | 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. |
| 6 | Droop Configuration | Enable | (0-1) | 0 | 0: Potentiometer<br>1: Fixed Set Value |
| | | Set Value | (0.0-10.0)% | 0.0 | |
| | | External Poten. Max. Value | (0-10.0)% | 10.0 | |
| 7 | Line Volt. Drop | Enable | (0-1) | 0 | 0: Disable; 1: Enable. |
| | | Set Value | (0.0-20.0)% | 3.0 | |

| No. | Item | | Range | Default | Description |
|---|---|---|---|---|---|
| | Compensation | | | | |
| 8 | Threshold Start Mode | Enable | (0-1) | 0 | 0: Disable; 1: Enable. |
| | | Start Threshold | (0.1-100.0)% | 20.0 | |
| | | Initial duty cycle | (0.0-100.0) | 40.0 | |
| 9 | 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. |
| 10 | AVR Trim Set | Volt. Trim Enable | (0-1) | 0 | 0: Potentiometer<br>1: Fixed Set Value |
| | | Clockwise Range | (0-100.0)% | 10.0 | Display +/- |
| | | Lower Limit Value | (-100.0-(-0.1))% | -10.0 | Adjustable range of PF controller. |
| | | Upper Limit Value | (0.1-100.0)% | 10.0 | |
| | | Lower Limit Volt. | (-10-10.0)V | -5.0 | Voltage range of PF controller. |
| | | Upper Limit Volt. | (-10-10.0)V | 5.0 | |
| 11 | Custom Curve Set | U/F Knee Curve Enable | (0-1) | 0 | 0: Not Used; 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 | |

| No. | Item | | Range | Default | Description |
|---|---|---|---|---|---|
| | | Knee Curve Y8 | (0-100.0)% | 100.0 | |
| PID Setting | | | | | |
| 1 | DC Compensation Enable | | (0-1) | 0 | 0: Disable; 1: Enable. |
| 2 | Input Voltage of Excitation Power Supply | | (0-450.0) V | 90.0 | |
| 3 | DC Compensation Factor | | (1-10) | 5 | |
| 4 | Max Output Duty Cycle | | (0-100.0) % | 100.0 | Max output duty cycle in excitation regulation. |
| 5 | PID Stability Potentiometer Select | | (0-1) | 0 | 0: Potentiometer<br>1: Fixed Set Value |
| PID Parameter | | | | | |
| 1 | PID 1 | KG Coefficient | (0-20.000) % | 1.000 | Coefficient of PID set value. |
| | | KP Gain | (0-2000.0) % | 155.0 | PID set value. |
| | | KI Stability | (0-2000.0) % | 1800.0 | |
| | | KD Derivative | (0-2000.0) % | 17.0 | |
| | | KE Derivative Filter Coefficient | (0-20.000) % | 1.000 | Derivative filter coefficient. |
| 2 | PID 2 | KG Coefficient | (0-20.000) % | 1.000 | Coefficient of PID set value. |
| | | KP Gain | (0-2000.0) % | 140.0 | PID set value. |
| | | KI Stability | (0-2000.0) % | 1600.0 | |
| | | KD Derivative | (0-2000.0) % | 15.0 | |
| | | KE Derivative Filter Coefficient | (0-20.000) % | 1.000 | Derivative filter coefficient. |
| 3 | PID 3 | KG Coefficient | (0-20.000)% | 1.000 | Coefficient of PID set value. |
| | | KP Gain | (0-2000.0)% | 160.0 | PID set value. |
| | | KI Stability | (0-2000.0)% | 1750.0 | |
| | | KD Derivative | (0-2000.0)% | 16.0 | |
| | | KE Derivative Filter Coefficient | (0-20.000)% | 1.000 | Derivative filter coefficient. |
| 4 | PID 4 | KG Coefficient | (0-20.000)% | 1.000 | Coefficient of PID set value. |
| | | KP Gain | (0-2000.0)% | 165.0 | PID set value. |
| | | KI Stability | (0-2000.0)% | 1700.0 | |
| | | KD Derivative | (0-2000.0)% | 13.0 | |
| | | KE Derivative Filter Coefficient | (0-20.000)% | 1.000 | Derivative filter coefficient. |

## 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 DVR internal parameters in standby mode (like delay setting) to avoid fault alarm or other abnormal conditions. 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, it will result in abnormal alarm; 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 monitor the data, click “Pause” button to suspend data monitoring, click “Stop” button to stop data monitoring. Click “Save Data” button can save the curve as csv or xml file, click “Load CSV” can load and view the saved curve file in CSV format.

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

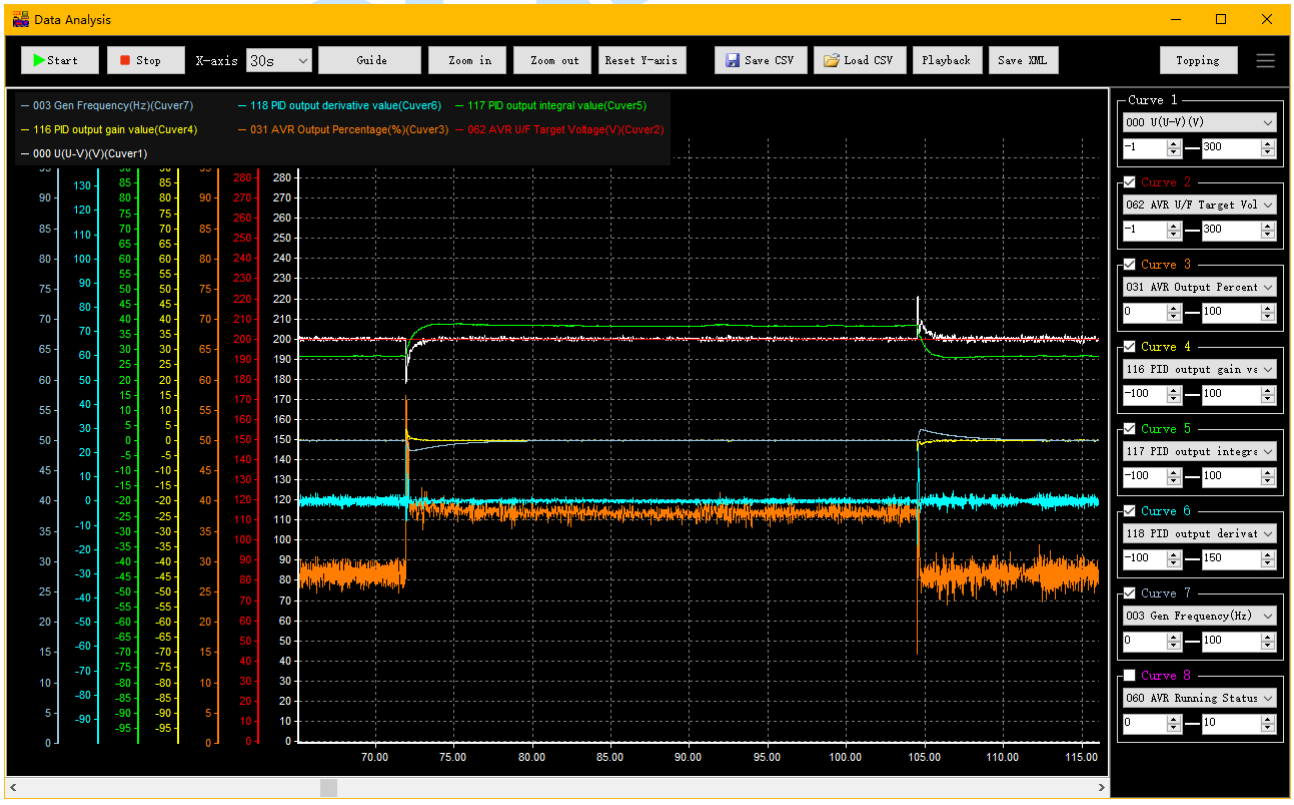



**Fig.30 Real-time Data Analysis Diagram on PC Software**

## 10 COMMISSIONING

- Check all the connection wires are correct and wires diameter is suitable;
- Set parameters (voltage, frequency, etc.) through USB interface via PC software;
- When using a potentiometer to regulate the voltage, set the DIP switch to the correct position according the generator's voltage level and frequency. If an external voltage regulation resistor (VR) is used, ensure the switch is set to the middle position. Rotate the rated voltage potentiometer knob while monitoring the output voltage on PC to get the rated voltage. When using fixed voltage and frequency settings, the rated voltage and frequency should be configured on PC;
- The under-frequency protection threshold is factory-preset internally (48Hz for 50Hz systems, 57Hz for 60Hz systems) and generally requires no modification; When using a potentiometer to adjust the under-frequency protection threshold, after setting it to a potentiometer mode, rotate the U/F knob to adjust the under-frequency protection threshold of DVR;
- Enable the threshold start mode, set initial duty cycle and proper PID parameter, and take necessary protective measures, then start the genset. When gen voltage reaches start voltage threshold, the voltage regulator enters soft start stage. 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 or potentiometer stability to meet dynamic characteristic demand of generator;
- If there are any other questions, please contact SmartGen's service.

## 11 TYPICAL APPLICATION

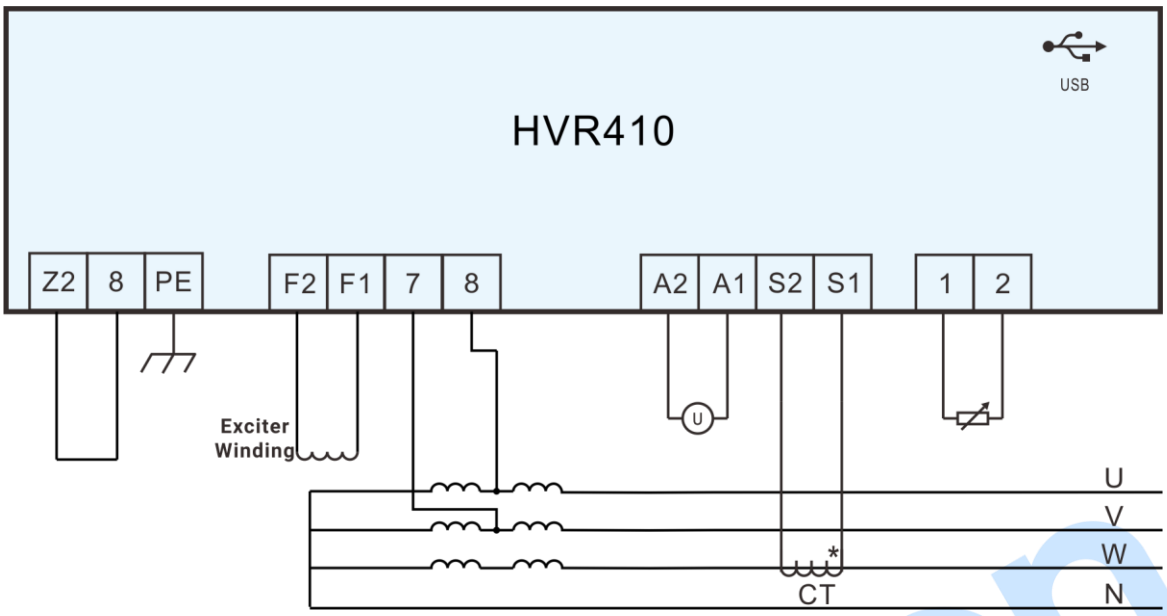



**Fig.31 380/440V SHUNT Generator Typical Application**

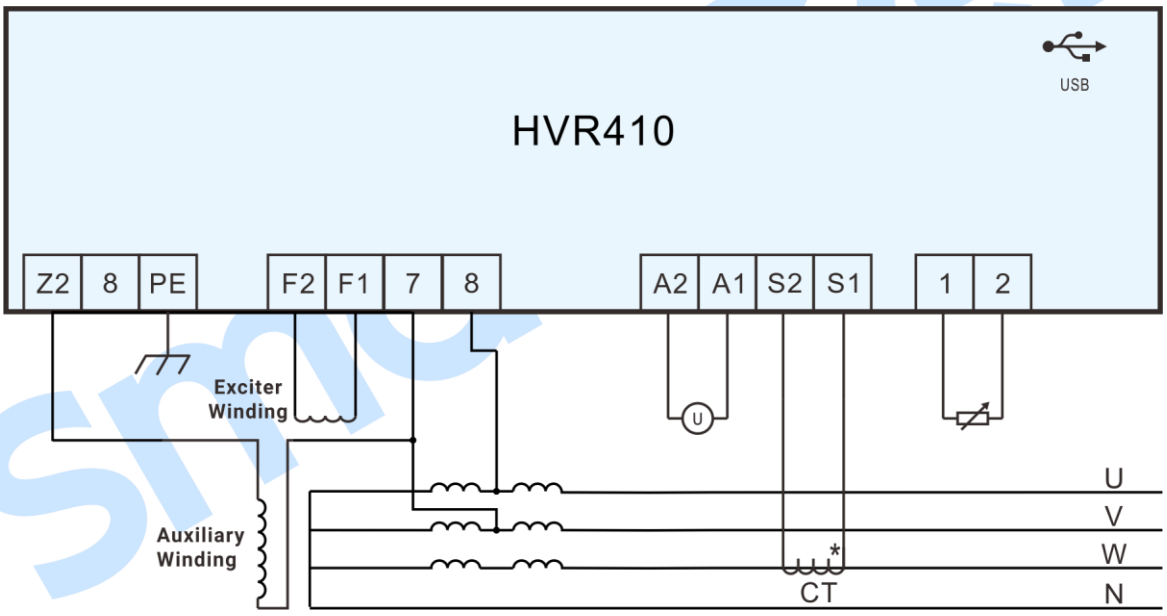



**Fig.32 380/440V AUXW Generator Typical Application**

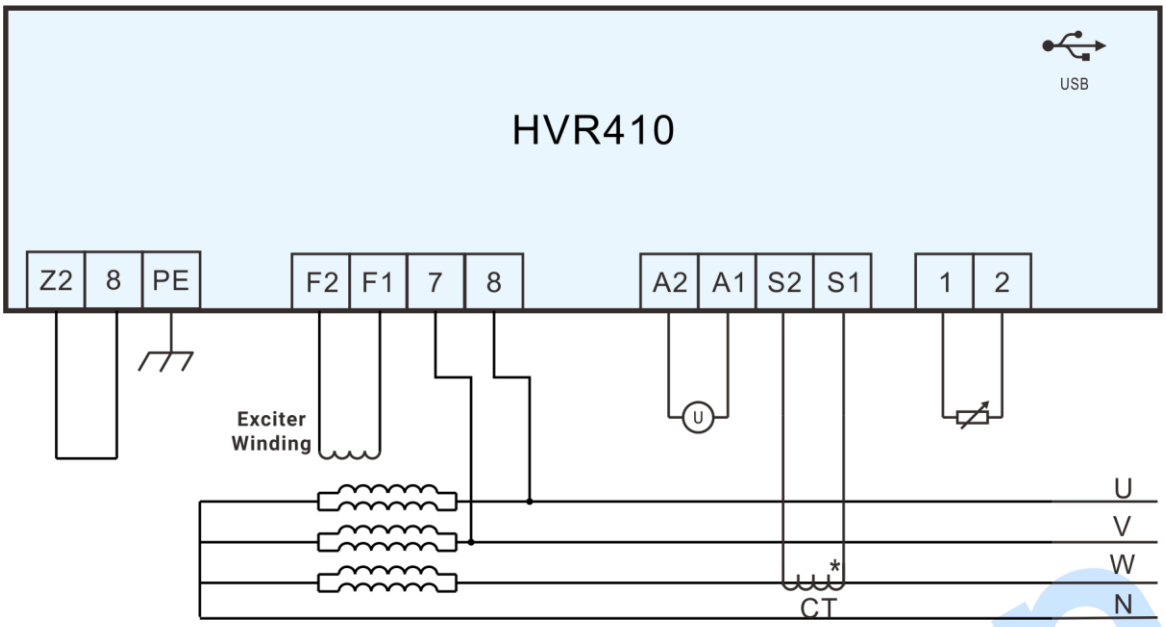



**Fig.33 110/220V SHUNT Generator Typical Application**

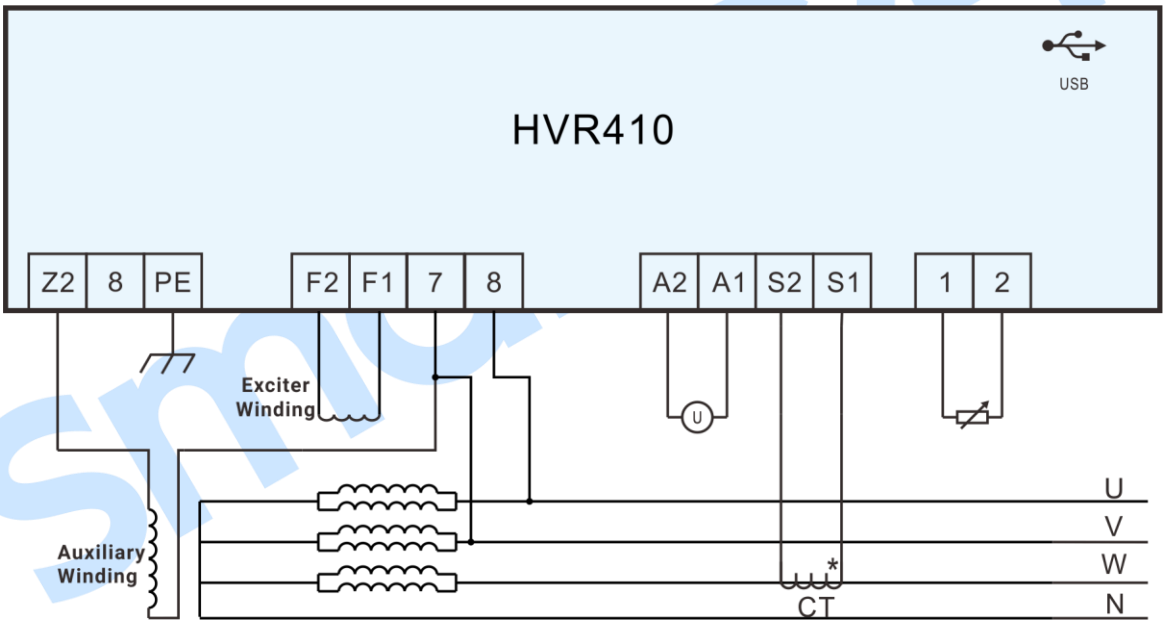



**Fig.34 110/220V AUXW Generator Typical Application**

## 12 INSTALLATION

### 12.1 OVERALL AND INSTALLATION DIMENSIONS

Unit: mm

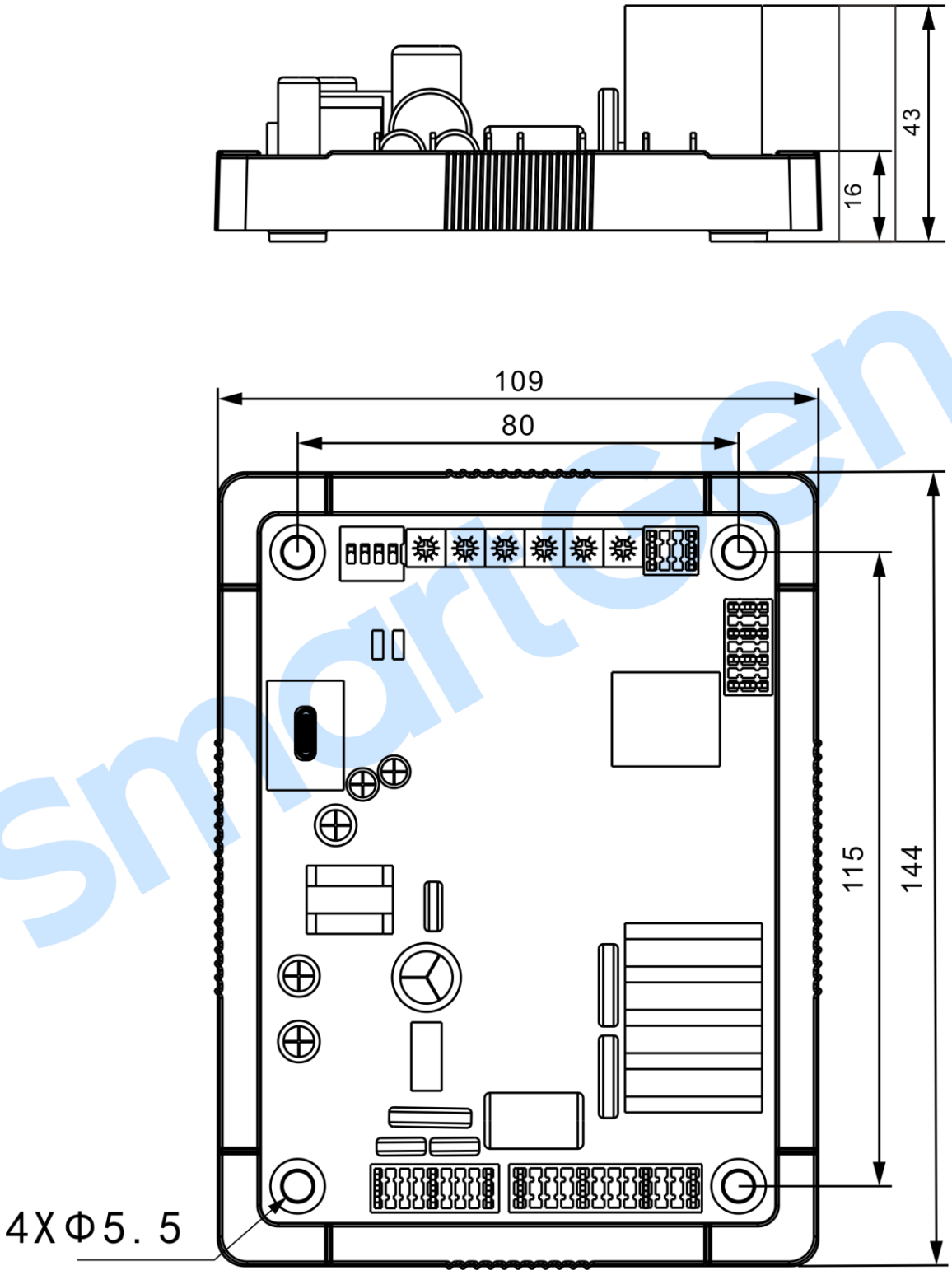



**Fig.35 Overall and Installation Dimension**

## 12.2 INSTALLATION METHOD AND RECOMMENDATION

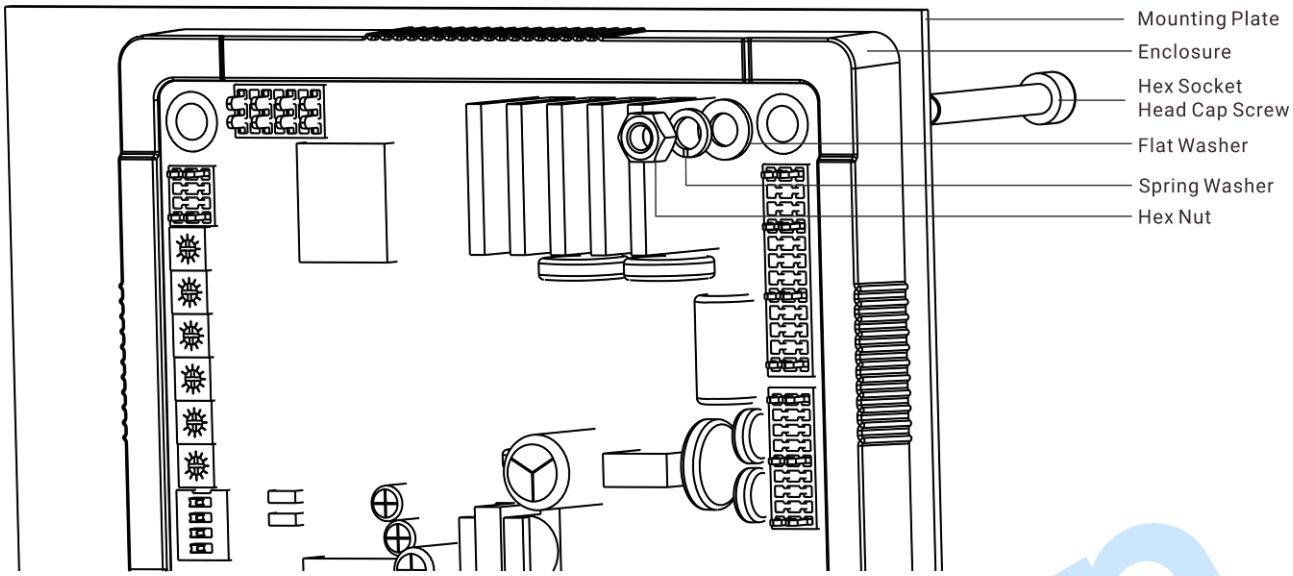



**Fig.36 Installation Method**

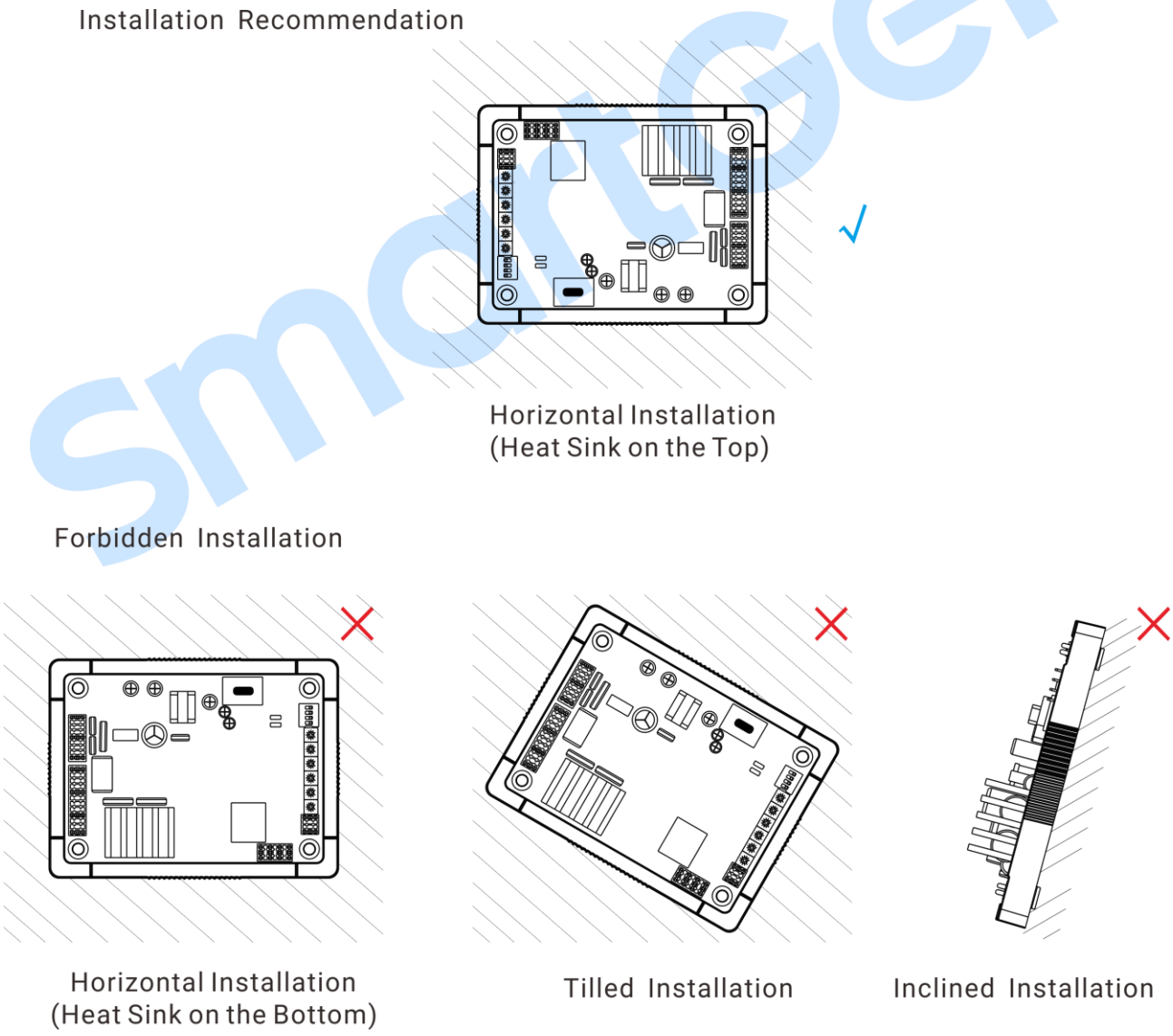



**Fig.37 Installation Recommendation**

## 13 FAULT FINDING

**Table 11 Fault Finding**

| Symptoms | Possible Solutions |
|---|---|
| Regulator Inoperative | Check if the power connections are normal; |
| Gen Voltage Unavailable | Check if the power fuse is normal. |
| Gen Voltage Low | Check if the set rated gen voltage is correct;<br>Check if the set U/F characteristic slope is correct;<br>Check if the generator is running at rated speed. |
| Gen Voltage High | Check if the set rated gen voltage is correct;<br>Check if the set U/F characteristic slope is correct;<br>Check if the generator is running at rated speed. |
| Gen Voltage Instability | Check if the connections of gen terminal voltage are normal;<br>Check if the PID parameter setting is proper, adjust PID parameter. |
| Potentiometer Instability | Check whether the current settings are fixed configuration values;<br>Check if the potentiometer adjustment range is set too small. |
| Alarm Indicator Flashing | Check PC to confirm the current alarm type and ensure that the corresponding alarm threshold is configured correctly. |

## 14 APPENDIX I SYMBOL AND TERM DEFINITION

**Table 12 Symbol and Term Definition**

| Symbol | Term | Remark |
|---|---|---|
| AVR | Automatic voltage regulation mode | |
| DVR | Digital Voltage Regulator | |
| 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 | |
| $E_V$ | Voltage trim 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 | |