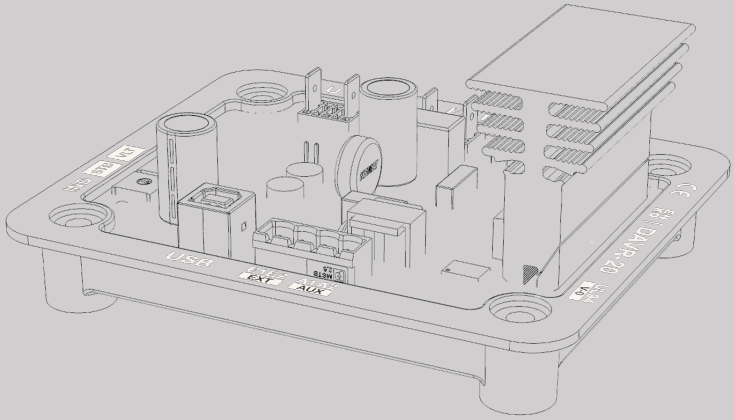
Digital Voltage Regulators



DAVR-20

USER MANUAL

INSTALLATION AND COMMISSIONING

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Revision History:

REVISION	Revision Date	Explanations	PR
R01	07/10/2023		
R02	04/02/2024	Parameter list order revised	M.A.
R03	17/09/2025	Updated parameter list	S.K.
R04	10/10/2025	Graphics update	S.K.

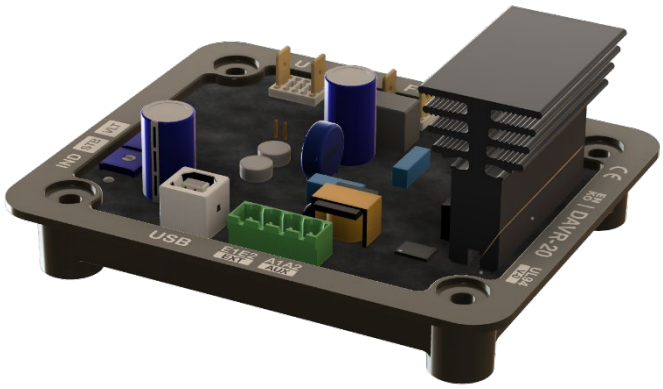
DAVR-20

(Digital Automatic Voltage Regulators for Brushless Alternators)

1- Product Description:

DAVR20 is a microcontroller based AVR unit, designed for brushless alternators as a high-performance voltage regulator at low cost.

Device is designed to suit a wide range of applications, delivering up to 5A continuous FIELD power under full operating conditions. Field drive is designed with SCR-DIODE configuration, which can pick up from as low as 6Vac RMS residual voltage levels.



The AVR unit senses two phases of the alternator simultaneously to calculate the TRUE RMS values of the voltage signals, which enables high precision voltage regulation, even with high-harmonic loads, where similar analogue AVRs fail to perform.

DAVR20 is also equipped with true OVER-EXCITATION protection control, independent of the alternator FIELD impedance. This ensures efficient protection of the generator in case of alternator malfunctions. Additional protections are also built-in as described further in this document.

This unit can be connected either in SHUNT mode or, with an AUXILIARY power winding configuration. Unit is configured as 2-phase sensing mode with phase-neutral option. User can select type of configuration from software menu. Voltage sensing can be set between 100Vac to 480Vac.Power connection to AVR is limited to 300Vac maximum and should be wired accordingly.

DAVR20 is mainly aimed for stand-alone generator applications with high performance. Stator current sensing is not available on the AVR and therefore, reactive load sharing is not possible.

All AVR parameters can be configured by the user, prior to operation. Integrated on-board USB com port (galvanically isolated) allows direct connection to the AVR and all parameters can be configured directly from the PC, without the need to connect external power to the device. This feature is particularly useful during system commissioning and/or tuning the generator set for customer's specific requirements.

AUX input signals can be programmed according to application requirements. Please refer to the "AUX Terminal Configuration Settings" of this user manual for dedicating special functions for this input.

The AVRs are designed and manufactured to very high standards for safe and reliable use. All components used in these devices are selected from "Approved Original Component Manufacturers" with traceable quality standards.

Electronic hardware is constructed into a robust plastic tray for easy and safe mounting on the alternator. These devices can be mounted directly onto the metal panel surface, or they can be mounted on rubber anti-vibration (AVM) suspensions for high-level vibration protection. The units are encapsulated with UL approved polyurethane material for high resistance against harsh environmental conditions with high RTI value.

DAVR20 is a programmable unit and please refer to the PC-Configuration tool manual to set the AVR parameters according to customer requirements. Check the factory "default" parameter list and make sure these parameters are suitable for your application. If not, PC-Configuration tool program can be used to set parameter values before operation.

1.1 Product marking:

DAVR20 is part of a family of “Digital Automatic Voltage Regulators”, designed and manufactured by ENKO and each version may have one or more options, and these options are defined in the device marking and ordering code form.

- DAVR20 Basic unit with specified characteristics
- DAVR20X OEM customer specific characteristics ID (if available)

Product name and model number, including all the terminal identifications are printed on the plastic tray. For on-line technical specifications and user manual information, scan the “QR code” on the back side of the AVR unit or check www.enkoelektronik.com web site. Getting the product information on-line ensures latest updated information is received.

1.2 User Manual guidance:

During installation, general safety measures must be taken, and all wiring must be made according to high-voltage installation standards.

Only professional technicians must attempt to install these devices. Damage to the device and/or to person can occur, if not installed properly.

Where required, WARNING messages are used in this manual.

⚠	*“WARNING MESSAGE”*

These warning boxes inform the user for critical precautions to be taken during installation and commissioning the AVR units for safe and reliable operation. Please follow the instructions given in this manual and where in doubt, please contact www.enkoelektronik.com for further assistance in your applications.

These devices comply to CE regulations for EMC radiation and immunity and UL94 for flammability and safety requirements. These conditions are only valid if the AVR is mounted directly in the alternator metal enclosure.

If the AVR is going to be located elsewhere, additional shielding is required. In more demanding applications, additional EMC filters are required. In this case, contact ENKO sales team for additional EMC accessories required to meet the regulations. More information is available for additional EMC filtering accessories, which can be supplied directly from ENKO.

If products are printed with a QR code, user can scan the code for detailed installation information and technical specifications for the AVR unit.

⚠	The AVR units are subject to hazardous voltages during operation. Special care must be taken when handling the AVR units mounted on the alternator. DO NOT contact the AVR units when the generator is running. Always switch off the generator before servicing the AVR unit.

⚠	Heatsink on the AVR unit may reach high temperatures, therefore, take necessary precaution before touching the heatsink surface during servicing. Damage may occur to human skin, if touched when the heatsink surface is hot.

2- Technical Specifications:

Parameter	Value	Conditions
Operating temperature range:	-35°C to +60°C	At full specified rating
	+60°C to +70°C with -5%/°C Excitation Current derating	Linear derating of Excitation current from +60°C to +70°C ambient temperature rise
Storage temperature range:	-40°C to +85°C	No direct exposure to radiant heat source
Sense voltage:	100Vac – 480Vac (576Vac max. phase-phase)	2-phase sensing, Phase-Neutral sensing configurations,
Sense voltage range:	100Vac to 480Vac	Software configurable with parameter setting
Voltage sensing type:	TRUE rms measurement	Resolving higher voltage harmonics
Operating frequency:	25Hz to 75Hz	Configurable operating frequency selection
Voltage adjustment:	On-board trimmer	±15% of selected range (set by parameter)
	External pot	±10% of on-board trimmer set voltage (set by parameter)
	Aux. analogue input	±15% of set voltage (set by parameter)
	Software parameter setting	Reference voltage can be set from the menu
Current sensing:	No stator current sensing available	
Power input to AVR:	Shunt connection	300Vac max.
	Auxiliary connection	
Excitation current:	5.0Adc max.	continuous
	7.0Adc max.	20 sec. max.
	10.0Adc max.	10 sec. max.
Field impedance range:	15Ω nominal value	5Ω to 50Ω (power limited to 700W max.)
Field drive:	SCR – DIODE controlled	Half-wave rectified sinusoid
Field Drive output power:	600W maximum continuous	(-35°C to +60°C)
	Derate by -5%/°C above +60°C ambient temperature conditions	Linear derating of FIELD drive output power from +60°C to +70°C ambient temperature conditions,
Voltage regulation:	≤0.5% of set value	<4% of frequency change
	True RMS reading	Regulation to True RMS value
Dynamic response time:	<300ms	<60% block load change
AUX control input:	External pot input	1KΩ for voltage trimming
	External analogue input	0.5Vdc-10Vdc (linear control) ±5Vdc voltage input
External pot detection:	Yes	Automatic detection of pot disconnection
Loss-of-sense protection:	Yes	Monitor and indication after set time delay
OEX protection:	Yes	Monitor and shut down after time delay (S/W configurable)
UFRO setting:	0-10% of nominal set frequency	Software settable knee-point frequency
Dynamic LAM function:	-V/Hz slope setting +V/Hz slope setting Prime mover recovery time delay	0%Ur/Hz to -20%Ur/Hz User settable parameter according to required performance
VOLTAGE setting:	±20% of selected range with trimmer	S/W parameter setting for Kp, Ki and Kd gains with S/W menu
STABILITY setting:	Fine tuning of Kp value with trimmer	

UFRO setting:	0% to -10% of nominal frequency setting	
External pot setting range:	±15% of set voltage value	
AUX input trimming:	±10% of input signal	
Indicators:	Single RGB LED	Multifunction indication for: - Normal operation - Alarm trigger - Communication
Assembly:	Encapsulated in single plastic tray	Suitable for vertical and horizontal mounting
Weight:	130gr	Without terminal headers
Dimensions:	127mm x 107mm x 58mm	Plastic enclosure with printed labels
Conformity to standards:	EN61000-2-4 EN60068-1-2-14-30	

2.1 General Features:

- Voltage sensing:
  - Connection with 2-phase, or phase-neutral configuration,
  - TRUE RMS voltage sensing,
- High accuracy voltage regulation:
  - Better than 0.5% regulation of set value between no-load to full-load change,
  - Capable of tight regulation with high harmonic content load conditions,
- Wide range of voltage input selection:
  - 100Vac to 480Vac sense input capability, (withstand 600Vac max input)
  - Sense voltage range selection by software parameter setting,
- Power connection to AVR unit:
  - SHUNT connection,
  - AUX power winding connection,
- High field-current capacity:
  - 5Adc continuous excitation current capacity,
  - 7A for 20 seconds,
  - 10A for 10 seconds,
  - Excitation output power is limited to 600W max.
- Excellent performance with high “block-load” change on the generator output:
  - Built-in LAM function,
  - Adjustable dynamic response
  - Independent setting of slope values
  - Built-in UFRO setting for frequency roll-off point adjustment,
- Auxiliary inputs:
  - External voltage trimming pot connection input,
  - Analogue voltage control input for external device interface,
- Adaptive stability control:
  - On-board stability setting pot,
  - Adaptive stability control for different alternator frame sizes,
- Built-in protection:
  - “OEX” (Over Excitation with IDMT protection characteristics) protection with latch shut-down feature (customised according to alternator FIELD winding impedance, factory setting only, not enabled)
  - “Loss of Voltage Sensing” protection with 2-phase operation and single-phase connection,
- Robust construction:
  - Built into non-flammable plastic tray for easy mount on the alternator or in the electric cabin,
  - Encapsulated against harsh environmental conditions,
  - UL compliant non-flammable encapsulation for maximum protection,
  - Terminal identifications printed on the plastic tray,
- LED indicator:
  - On-board LED indicator for warnings and status indication
  - RGB LED for easy status identification,
- Conformity to standards:
  - CE safety for emissions and immunity,
  - UL94 non-flammability,
- Mechanical dimensions are shown in figure_3,

2.2 Mechanical Dimensions:

Mechanical dimensions of DAVR20 are shown in the drawing below:

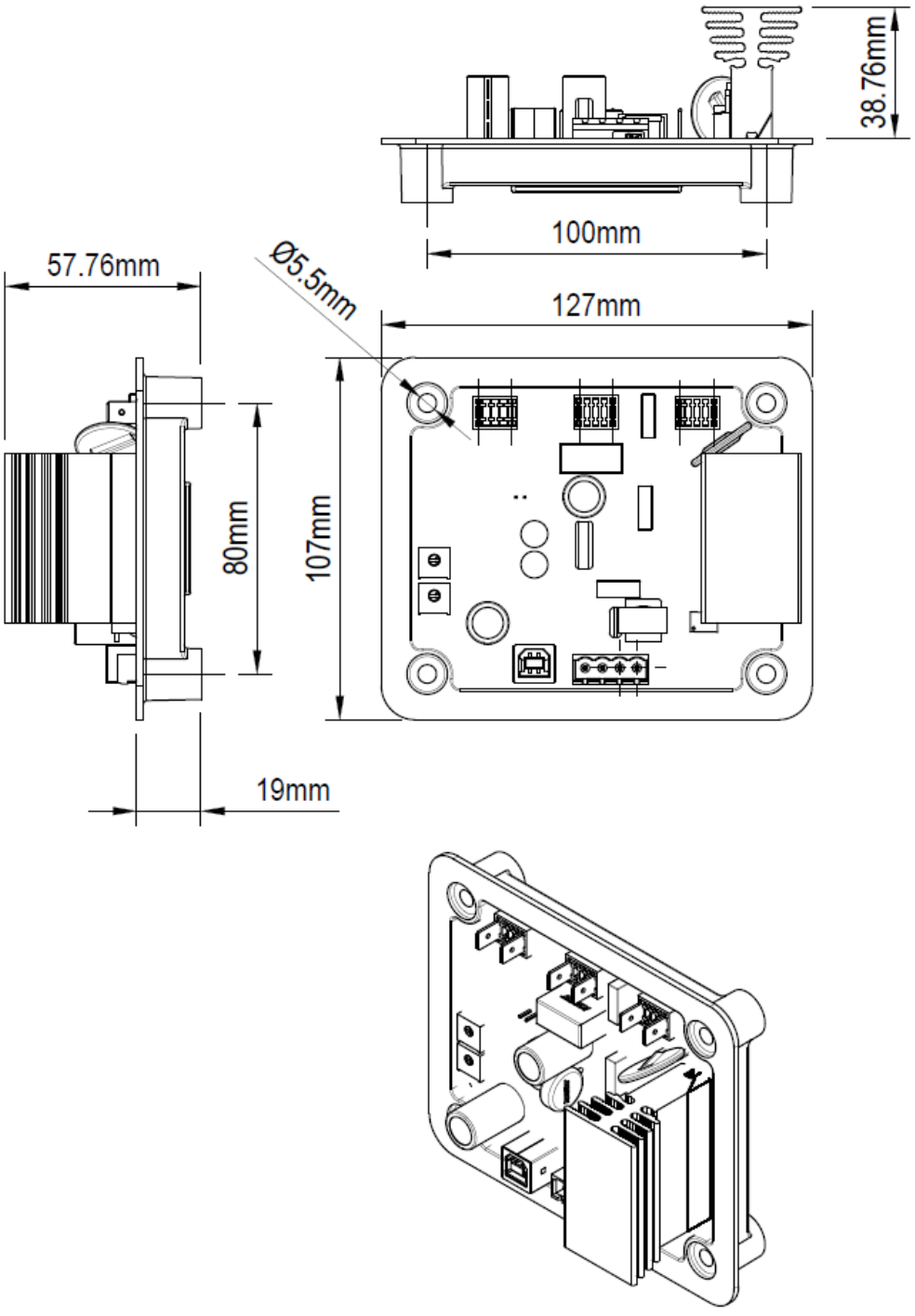


Figure 1: DAVR20 Mechanical dimensions (mm)

2.3 Mounting:

Mechanical mounting of DAVR20 is shown in figure_2 below. These AVR units are designed for RIGID mounting but for very high vibration applications, it is recommended that; rubber Anti Vibration Mount (AVM) fittings are used between the AVR body and the mounting plate.

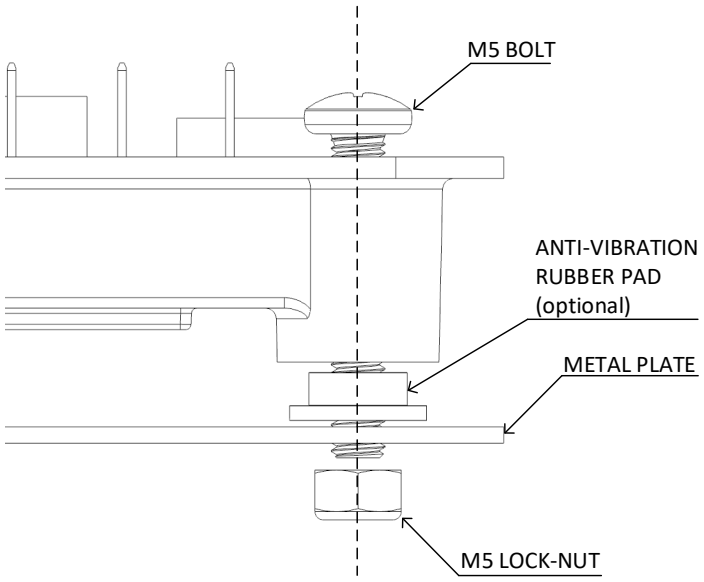


Figure 2: DAVR20 mounting

If the AVR is mounted onto a metal plate with rigid mounting technique, ensure that the locking-nut is used to avoid loosening of the nuts due to engine vibration in the long-term use.

⚠	Do not exceed the tightening torque limit when mounting the AVR unit. Recommended torque is 3Nm (5Nm max). Use torque-controlled tools to ensure correct tightening force. Failing to do so may cause the AVR plastic case to crack and AVR may not operate properly.

Ensure that the plate surface is flat prior to mounting the AVR unit. Mounting on a rigid surface with uneven geometry may damage the sensitive internal components of the AVR due to mechanical deformation of the plastic enclosure.

Select the appropriate type of anti-vibration rubber mounts based on application requirements. Verify that the bolt length is suitable for the combined thickness of the plate and any anti-vibration mount used. It is essential that all four mounting holes of the AVR unit are securely fastened to the plate before operation.

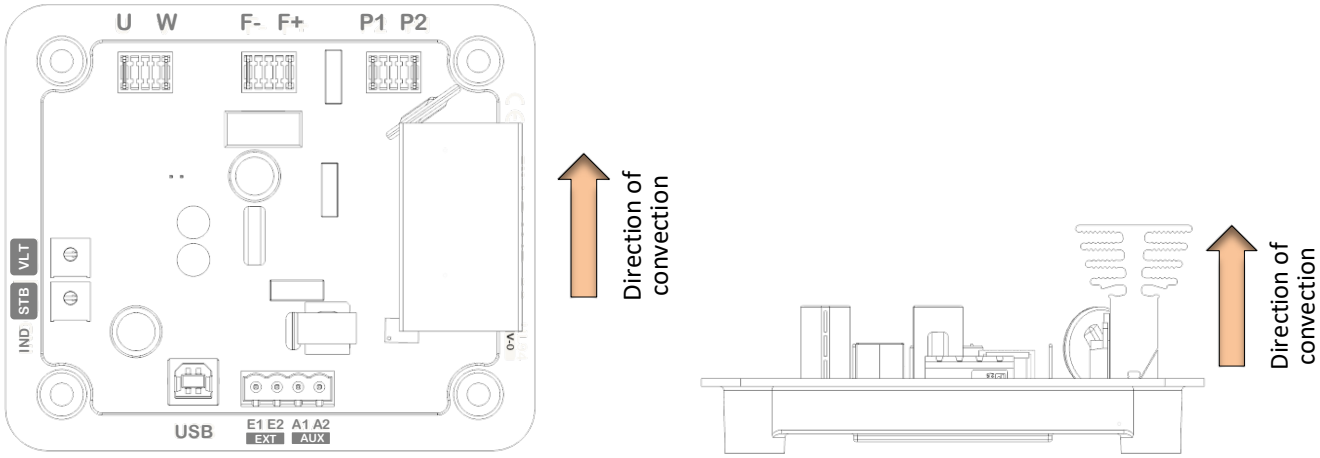
The standard mounting orientation for the AVR is vertical; however, horizontal mounting is permissible if necessary. Do not install the AVR unit with the heatsink facing downward, as this will negatively affect its operational temperature range. Avoid placing the AVR in completely sealed, small enclosures. Where possible, install the AVR in a ventilated location to facilitate heat dissipation.

When connecting the cable harness, ensure that no cables physically come into contact with the heatsink. Prevent cables from becoming congested over the AVR unit. Each cable harness connected to the top and bottom terminal rows should be routed directly away from the AVR, avoiding crossover over the unit.

The AVR heatsink is potential-free and remains isolated from the live parts of the unit. All terminal connections on the AVR are live and may present hazardous voltage levels relative to earth. Exercise caution when handling the unit.

3- Installation:

DAVR20 can be installed either in the generator control cabinet or on the alternator. For wiring of the AVR unit, please refer to this manual at every step and ensure correct wiring of the terminals, based on the wiring of alternator stator winding configuration. If further information is needed during installation, contact authorised service, or get in touch with sales@enkoelektronik.com



Vertical mount position

Horizontal mount position

Follow the instructions during mounting and installation wiring to comply with UL regulations. AVR unit must be mounted in a suitable location on the alternator such that, direct reach to AVR or any of its terminals should not be possible without removal of a cover, which is secured with safety screws/bolts. The AVR location must be furnished with suitable labels for “Hazardous Voltage” warnings.

Ensure safe-locking nuts are used for mounting the AVR unit to alternator frame. The nuts must be resistant to vibration and should not get loose during operation. All wiring harness must be labelled and secured suitably such that, cable connections on the AVR unit terminals do not move or shake during operation.

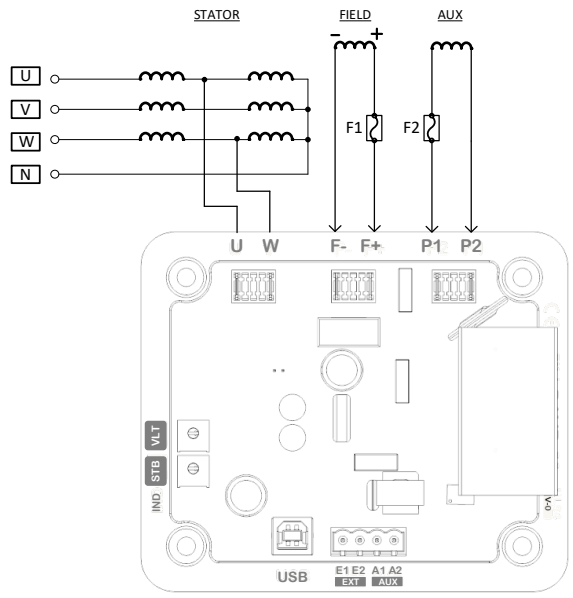
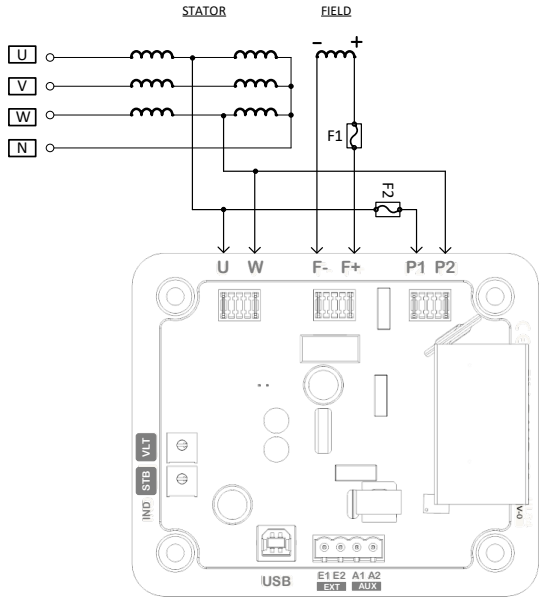
It is preferred that the AVR is mounted in a well-ventilated location on the alternator body. If mounted in a completely closed container, make sure the free space around the AVR is maximised and no other heat sources are present in the location, where the AVR is mounted.

Suitable fuses must be used in series with the EXCITATION output and POWER inputs of the AVR unit. Please refer to the fuse selection table in this document for proper operation of the AVR unit. The fuses can be either mounted on to the alternator body, or they can be cable-mounted fuse holders. Failing to comply to these installation regulations may cause incompatibility to UL standards.

In some demanding applications, a higher EMC shielding may be required. In this case, additional EMC filtering and “Faraday Cage” packaging may be necessary. In such applications, additional EMC accessories can be obtained directly from ENKO. Please contact sales@enkoelektronik.com for further assistance.

3.1 Typical Installation configurations:

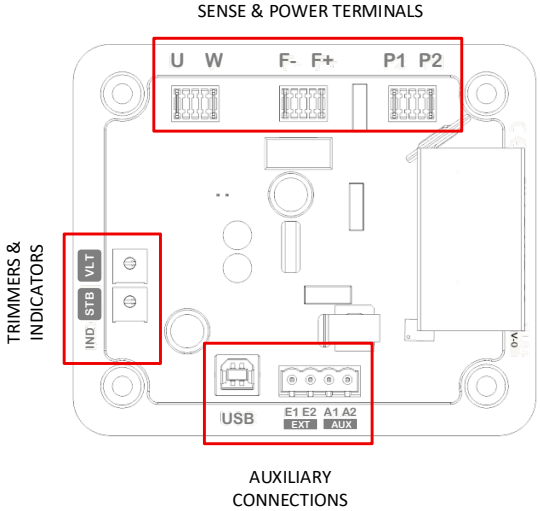
DAVR20 can be installed in different configurations, based on the application requirements. It is possible to connect the AVR either in SHUNT or AUXILIARY configuration and in all cases, a safety fuse should be fitted with the wiring. Typical installation is shown in the table below:

DAVR20 with AUX power connection	DAVR20 with SHUNT power connection
	

Please refer to the connection diagrams in the above table for different configurations with or without AUX winding. For UL compliance, F1 and F2 fuses MUST be used and for correct selection of the fuse values, please refer to the “Fuse Selection” chapter of this manual.

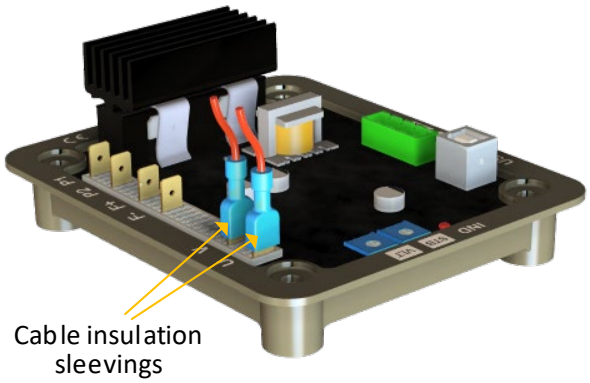
3.2 Definition of Terminals & Indicators:

DAVR20 is equipped with terminals, trimmers, and indicator for interfacing with the alternator and the user side. The terminals are grouped according to their functions, and these are shown in the figure below:



Different types of terminals used are used on the AVR unit, depending on the type of signal to and from the AVR. For POWER connections, “fast-on” terminals are used and special care is required for reliable installation.

Each terminal connection in the cable harness MUST be insulated with a suitable insulation sleeving. Please refer to the picture below:



The cables used in the cable harness and the sleevings must comply to UL standards and should be selected according to the installation requirements, based on the operating temperature, voltage and vibration conditions. The cable harness MUST be secured safely by suitable cable ties, close to the AVR terminal connections such that, the wire harness should not be allowed to vibrate freely during operation. Correct fast-on terminal size must be used to match the AVR male terminals.

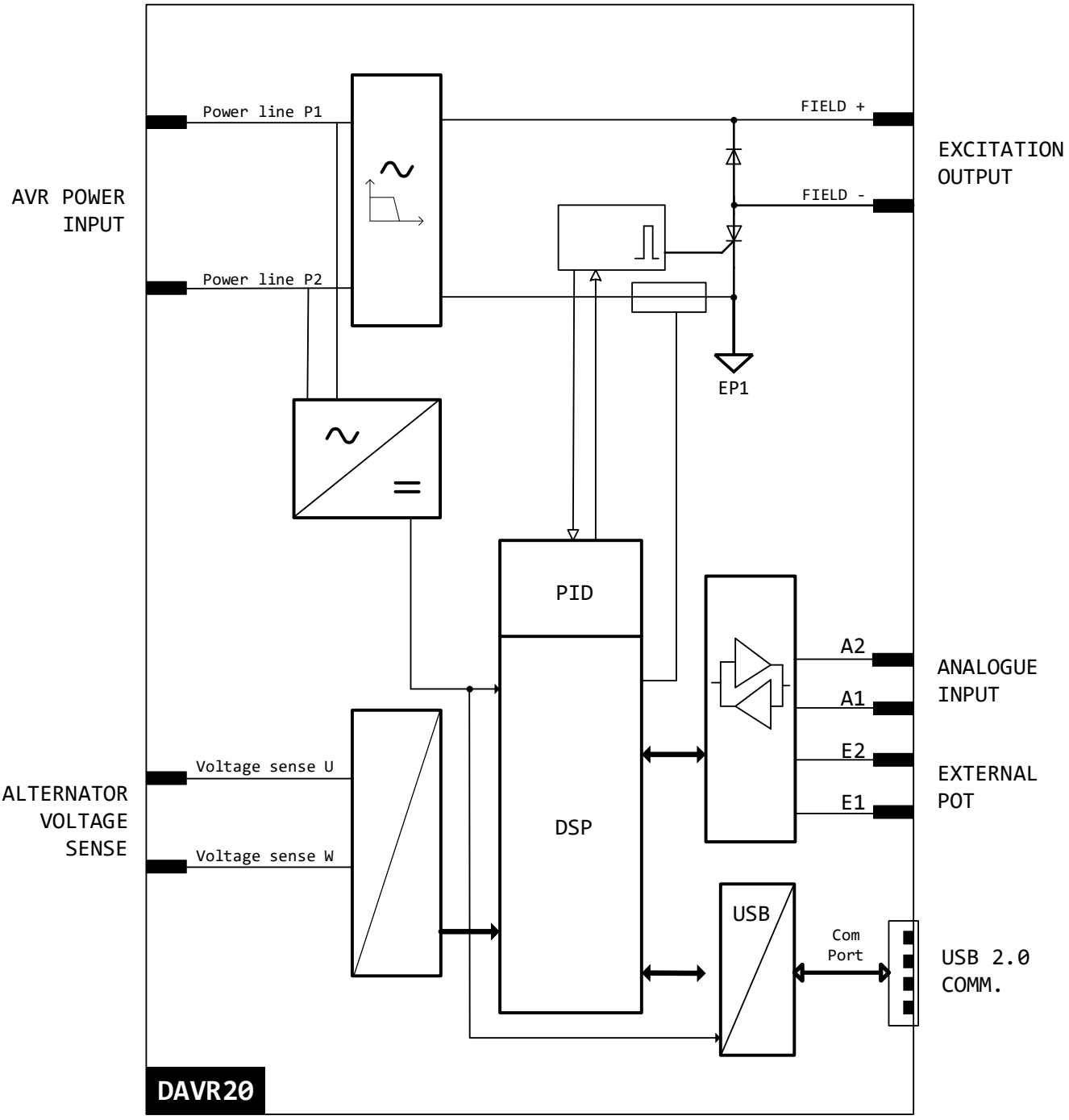
All POWER connections must be made according to regulations mentioned above. Failing to do so may jeopardise the UL compliance.

F1 and F2 fuses may be either mounted onto the alternator body in a suitable fuse holder, or the fuses can be installed into the cable harness with suitable cable type fuse holders. User must select a suitable fuse holder based on their application requirements. Ensure that, fuses can be replaced freely without undoing the cable installation, in case the fuse needs to be replaced.

⚠	Ensure that the cable harness does not block the direction of convection during installation. based on the AVR mounting position, cable harness to and from the alternator should not block the airflow around the heatsink module on the AVR unit. All wiring harness MUST be installed below the “AVR body clearance hight” so that, the air flow through the AVR heatsink fins is not reduced or blocked. Always observe the “direction of convection” as shown in the above drawings.

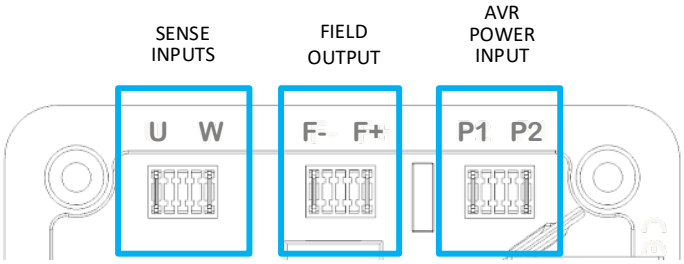
Terminal cable sizes:			
Terminals:	**AWG**	**Diameter (mm)**	**Area ($mm^{2)}$**
U, W	15	1.42	1.5
F-, F+, P1, P2	13	1.82	2.5
A1, A2, E1, E2	17	1.15	1.0
USB	Use USB Type-B cable with moulded terminal only		

3.3: System Block Diagram:



3.4: Alternator Voltage Sensing:

DAVR20 is a “2-phase sensing” AVR. Voltage sensing inputs should be connected across U and V phases of the alternator. If required, DAVR20 can also be connected in “phase-neutral” configuration. Voltage sensing terminals are shown in figure below:

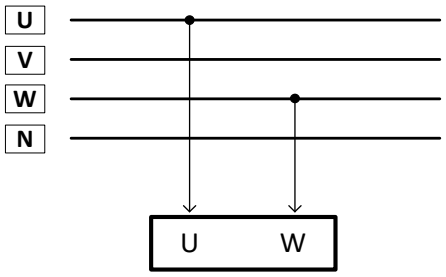
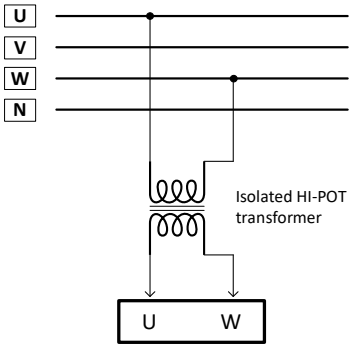


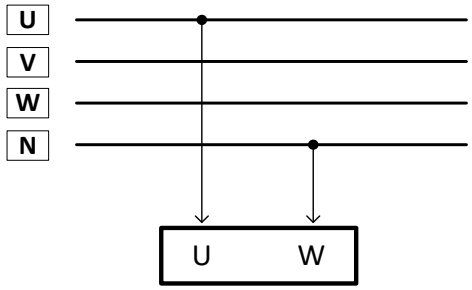
The voltage sensing terminals are “high impedance” inputs and can be connected in various configurations as shown in table below. Maximum voltage withstand limit of sensing terminals is limited to 480Vac +20% maximum limits. Therefore, when connecting the AVR unit, ensure that correct voltage sensing range is selected from the configuration S/W and the terminals are connected correctly on the alternator.

The voltage range selection parameter indicates the nominal voltage regulation reference point, when the “VOLTAGE ADJUST” trimmer is set to its MIDDLE position on the AVR unit.

DAVR20 can only regulate the voltage at the point of their sensing terminal connections. Therefore, in the following paragraphs, voltage range selection and voltage adjust pot act with respect to the voltages seen across the sensing terminal connections. User must select the correct voltage sensing range and set the pot position according to their application requirement.

Possible voltage sensing connection configurations for DAVR20 are shown in the table below:

Voltage sense connections	Direct connection *(Either from stator main terminals or from winding mid-point connections)*	Hi-pot transformer connection
2-Phase Connection:		

Phase – Neutral connection		Not applicable

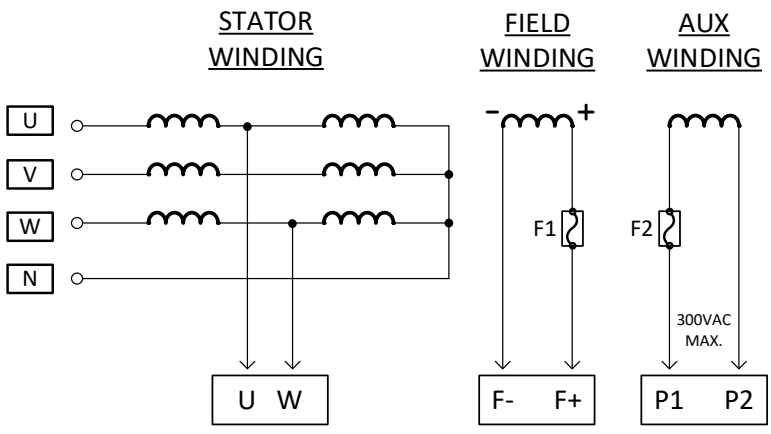
	Voltage Sense connections must match the selected voltage range of the AVR unit. Refer to the voltage range selection topic of this user manual before making connections to the alternator. If the AVR is connected in SHUNT mode, make sure that; the POWER SUPPLY input to the AVR is not exceeded, it is limited to 300Vac maximum (absolute maximum allowed voltage limit).

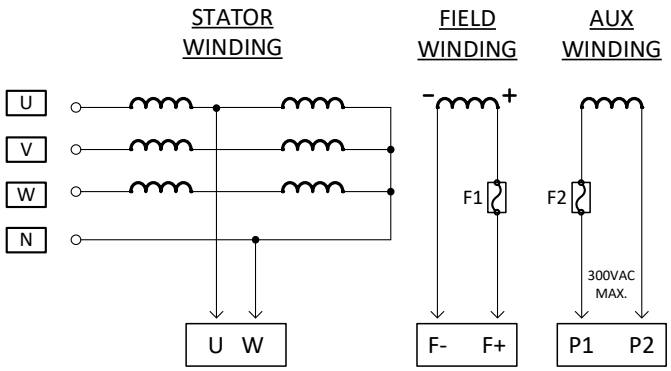
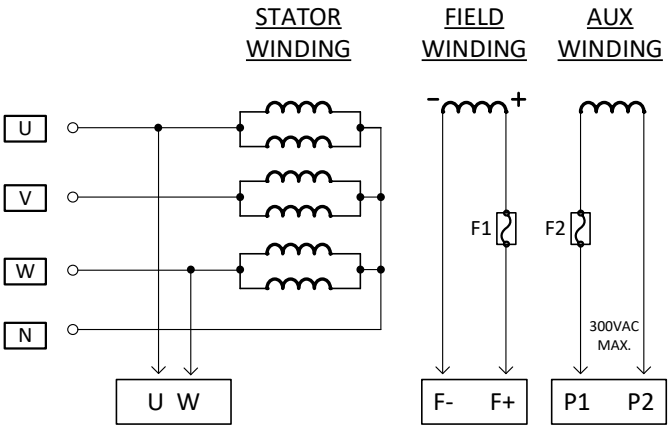
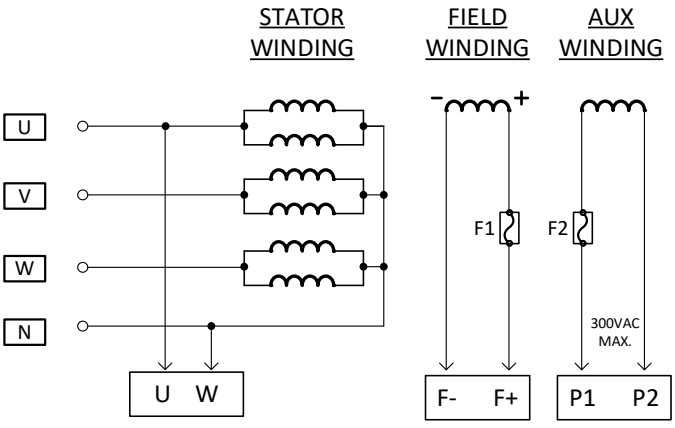
3.5: Power Supply and FIELD winding connection:

Power Supply input of DAVR20 is limited to 300VAC / 600W maximum. In any application, exceeding this voltage level may damage the AVR unit. Take special care when connecting the voltage sensing input and AVR power supply input in SHUNT connection mode.

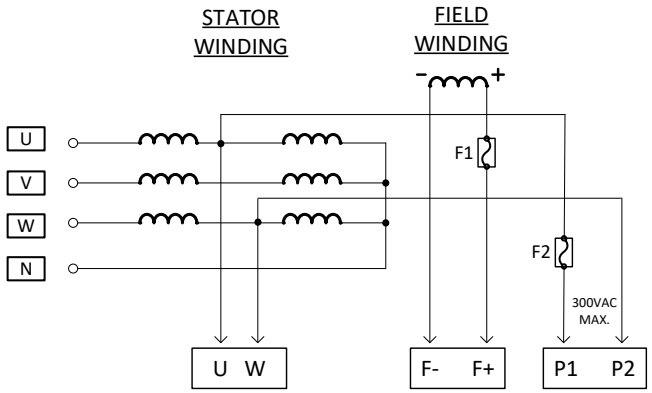
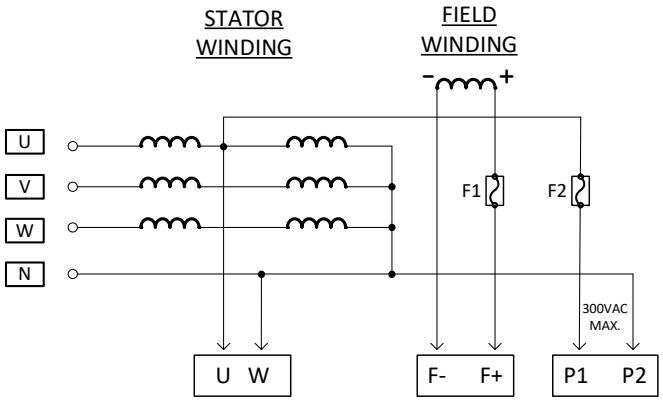
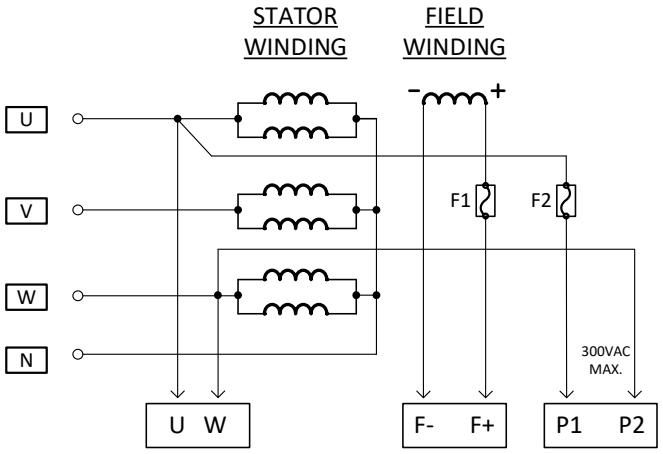
Power to AVR can be connected in “SHUNT” mode or “AUXILIARY” supply mode as required. Possible connection configurations are given in the table below for different configurations of the alternator stator winding arrangements. Please refer to the figure above for AVR POWER and FIELD output terminals on the AVR unit.

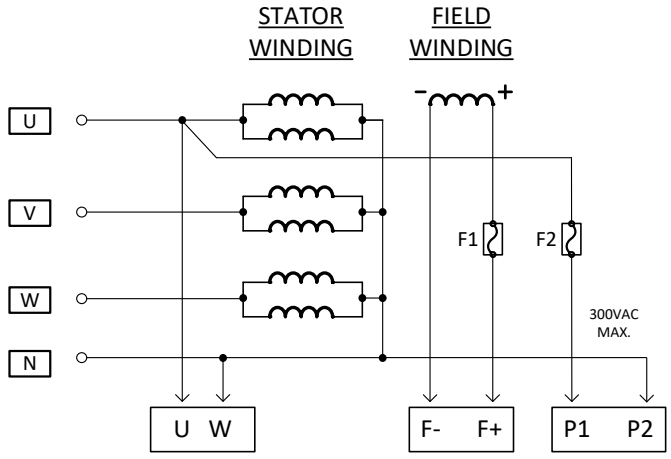
Possible power and sensing connection configurations are shown in table below for DAVR20 series AVR units. In this table, high-potential transformer connection configurations are not shown. For high-potential connection with insulating transformers, please refer to the related chapter of this manual.

Configuration	WIRING SCHEMATIC WITH AUXILIARY WINDING
Connection with **AUXILIARY** winding and “2-**phase**” voltage sensing, *(Y-Star series connection, 12 leads)*	

Connection with **AUXILIARY** winding and "**phase-neutral**" voltage sensing. *(Y-Star series connection, 12 leads)*	
Connection with **AUXILIARY** winding and "**2-phase**" voltage sensing. *(YY-Star parallel connection, 12 leads)*	
Connection with **AUXILIARY** winding and "**phase-neutral**" voltage sensing. *(YY-Star parallel connection, 12 leads)*	

	Maximum voltage across power supply terminals of DAVR20 is limited to 300Vac max. Do not exceed this limit in all applications, considering the over-shoot percentage of the AUXILIARY winding, when the stator load is removed suddenly. Ensure this limit is not exceeded under all operating conditions.

Configuration	WIRING SCHEMATIC IN SHUNT CONFIGURATION
Connection with **SHUNT** mode and "**phase-phase**" voltage sensing, *(Y-Star series connection, 12 leads)*	
Connection with **SHUNT** mode and "**phase-neutral**" voltage sensing, *(Y-Star series connection, 12 leads)*	
Connection with **SHUNT** mode and "**phase-phase**" voltage sensing, *(YY-Star parallel connection, 12 leads)*	

Connection with **SHUNT** mode and "**phase-neutral**" voltage sensing, *(YY-Star parallel connection, 12 leads)*	 *NOTE: In this example, P1 - P2 power supply connection is made between phase and neutral of stator winding. User should consider the FIELD winding impedance when selecting this connection option.*

3.6: Notes on P1-P2 Power Connection to AVR:

Power input, P1 and P2 of DAVR20 is designed as "floating" connection with respect to the sense inputs and therefore can be connected across "phase-phase" terminals or "phase-neutral" terminals of the alternator in SHUNT mode connection. Always connect P1 to "U-phase" of the alternator if wiring is in SHUNT mode. P2 can either be connected to "W-phase" or "Neutral" terminal of the alternator.

It is always a better practice to connect the power to AVR, such that a useful range of the power input can be used over the full power rating of the generator. If maximum required FIELD current is less than 2A, then it may be a better practice to connect P1 and P2 across phase and neutral line of the alternator, if SHUNT connection is used.

In all applications, DO NOT EXCEED 300VAC maximum input voltage and 600W power limit of P1 and P2 terminals.

3.6.1: POWER limitation of DAVR20:

DAVR20 can drive a wide range of excitation windings with impedance values ranging from 5Ω to 50Ω. As the maximum power input voltage to AVR is limited to 300Vac (P1 and P2 terminals), maximum excitation current is also limited to 5Adc maximum in continuous operation over the specified operating temperature range.

Apart from voltage and current limitation of the excitation drive of the AVR unit, maximum power that the AVR can deliver into any excitation winding is also limited and it should not exceed **600W** maximum under any operating conditions. Please refer to the related chapter of this manual to learn more about the limitations of the AVR's excitation drive capacity.

If the installation allows better ambient conditions for the AVR (operating below maximum specified temperature limits), it is possible to exceed the 600W limit, provided that excitation maximum current limit and maximum power input voltage limits are not exceeded.

3.7: Connection with high-voltage transformer:

If the application is for high-voltage stator winding, then it is mandatory to use an isolation step-down voltage transformer between the stator windings and sense voltage terminals of the AVR unit. In this case, sensing voltage selection of the AVR unit and transformer secondary voltage must match.

In SHUNT mode connection with isolation transformer, if same transformer is used for both sense and power supply, limited impedance of the transformer may degrade the voltage sensing signals, when maximum field load is reached. Unless the transformer power rating is calculated for ohmic voltage drop, it is a better practice to use different transformers for sensing and power supply inputs to the AVR or use AUXILIARY winding connection to power the AVR unit.

In any case, do not exceed the limits of the power supply input terminals P1 and P2 as well as the sensing terminals of the AVR unit. Make sure that; correct voltage sensing range is selected on the AVR unit and isolation high-voltage transformer secondary voltage specifications also match the selected voltage sensing range of the AVR unit.

"EXCITATION and AVR POWER INPUT" Terminals identification:			
DAVR20 Terminal ID	**Connection**	**Rating**	**Terminal group**
F-	Excitor winding –'ve terminal	5Adc (continuous) 7Adc (20 seconds) 10Adc (10 seconds)	SENSE and POWER TERMINALS GROUP
F+	Excitor winding +'ve terminal		
P1	AVR Power input connection (Shunt, AUX)	300Vac (max.) 600W (max.)	
P2			

3.8: "Auxiliary & Communication Terminals" connections:

AUXILIARY signal connections and COMMUNICATION port connections are placed on the bottom side of the AVR unit. These signal terminal connections are arranged as "screw" type connections and care must be taken when preparing the cable ends for these terminals.

Do NOT strip the cable ends more than the depth of the screw-terminal insert hole. Failing to do so may cause momentary or permanent short circuit between adjacent cable connections, which may cause the AVR to malfunction during operation.

3.8.1: Analogue Signal connections:

DAVR20 has on-board "Analogue Signal" connection inputs for interfacing with external peripheral devices to control AVR behaviour under specific operating conditions. Analogue signal input terminals are identified as A1 and A2 and can accept voltage signals only. For more detailed information, please refer to the related topic in this user manual

Terminal identification and ratings are shown in the table below:

"ANALOGUE" signal input terminals identification:			
DAVR20 Terminal ID	**Connection**	**Rating**	**Terminal group**
A1	Screw type terminal with AWG17 or AWG18 cable size (A1 terminal is GND)	0-10Vdc ±5Vdc	"AUXILIARY & COMMUNICATIONS" Terminals group
A2			

	"Auxiliary & Communication" terminals are galvanically isolated form the POWER input terminals. There is no galvanic isolation between the AUX terminals and the COM port. Therefore, if the AUX inputs are connected to an external control system, ensure that galvanic isolation is NOT violated under all operating conditions.

3.8.2: External Pot connection:

DAVR20 has "External Potentiometer" connection terminals to set the AVR voltage regulation reference value within the limits, set by the configuration parameters. For more detailed application information please refer to the related chapter of the user manual.

Terminal identification and ratings are shown in the table below:

"EXTERNAL POT" terminals identification:			
DAVR20 Terminal ID	**Connection**	**Rating**	**Terminal group**
E1	Screw type terminal with AWG17 or AWG18 cable size	1KΩ/1W Potentiometer (two-wire configuration)	"AUXILIARY & COMMUNICATIONS" connection terminals group
E2			

	E1-E2 External Potentiometer inputs are galvanically connected with AUX terminals. Precautions MUST be taken to ensure proper installation of the external pot connections of DAVR20 under all operating conditions.

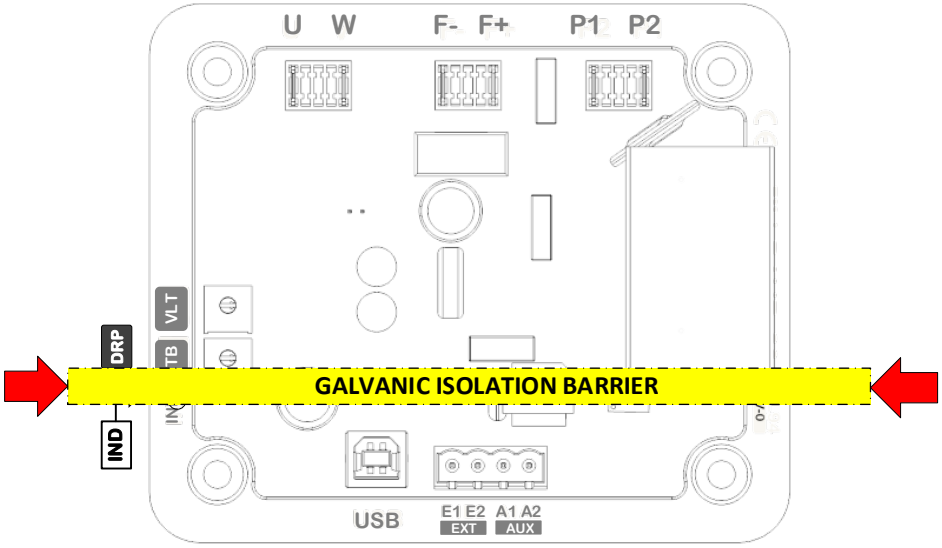
3.8.3: Communication Port Connection:

DAVR20 is fitted with a USB Type-B communication port socket for device configuration. This port is "Galvanically Isolated" and can be connected to PC during device configuration. Since the port is isolated, it is possible to monitor AVR performance while the alternator is running. Ensure that isolation limits are not exceeded during installation.

Terminal identification is shown in the table below:

"USB" Communication port identification:			
DAVR20 Terminal ID	**Connection**	**Rating**	**Terminal group**
USB	Type-B USB cable connection	Galvanically isolated to 500Vac	"AUXILIARY & COMMUNICATIONS" connection terminals group

	Galvanic Isolation of the AVR is provided against the sense and power connection side of the AVR. Therefore, USB port and Analogue AUX terminal signals are connected to the same power supply, which is galvanically isolated from the sensing and power connection of the alternator. Isolation is 500Vac, if higher isolation levels required, please contact the AVR manufacturer.



3.9: Trimmers and Indicators:

DAVR20 unit has integrated trimmers on board to manually set critical parameter values, if necessary, during commissioning. Onboard trimmers are shown in the table below:

On-board Trimmers & Indicators:			
DAVR20 Trimmers ID	**Connection**	**Rating**	**Terminal group**
VLT	VOLTS trimmer	±15% of set parameter value	"TRIMMERS & INDICATORS" Group
STB	STABILITY trimmer	K_P setting of PID parameters	

There is also a STATUS indicator LED integrated with the AVR unit. This indicator signals the status of the AVR during operation. It is an RGB LED, and the status indication is coded with colour and intermittent operations of the LED. For more detailed information about the LED indicator signals, please refer to the related chapter in this user manual.

The warning LED signal code is given below:

- GREEN for NORMAL operation
- RED for ALARM and UFRO
- BLUE flashing for USB communication

4- Voltage Regulation:

DAVR20 is a 2-phase sensing AVR, and it regulates the voltage seen across its "VOLTAGE SENSING" terminals, U-W phases. Since the AVR is designed to regulate the voltage across its sense terminals, it is recommended to set the correct voltage sensing range using PC-Tools configuration software (please refer to PC-Tools configuration software section of this manual) according to the stator wiring configuration.

There are three methods to set the regulation voltage reference on the AVR unit:

1. VLT pot position on the AVR unit,
2. EXTERNAL POT connection on the AUX terminals,
3. ANALOGUE signal input connection at the AUX terminals,

4-1. "Voltage regulation set point" and VLT POT setting:

Onboard VLT pot allows the user to set the alternator voltage during operation. Nominal voltage regulation set point value of the VLT pot can be set by software configuration parameter, [P100]. The VLT pot voltage setting range is selected with parameter, [P139] as a percentage of the parameter value of [P100] over full VLT pot adjustment range.

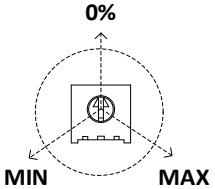
Parameter number	Parameter Description	Units	Min-Max range	Explanation
[P100]	"Nominal RMS Voltage Set" value. (U-W phase-phase voltage reference value)	VOLT (rms)	100 - 480	Adjustment range: 100Vac RMS to 480Vac RMS
			100	Factory default set value
[P139]	"Volts Trimmer Effective range" value. (VLT Pot adjustment range)	%	0 - 30	Adjustment range: ±0% to ±15% of P100 parameter set value, (factory default value: 30)

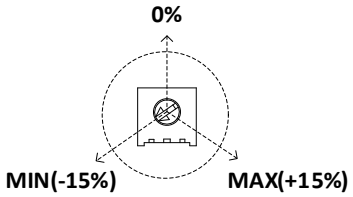
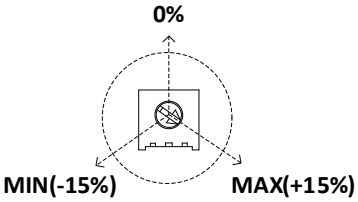
EXAMPLE:

Set voltage regulation to 380Vac and VLT pot setting range to ±15% (323Vac rms to 437Vac rms):

- Set parameter [P100] = 380
- Set parameter [P139] = 30

The result is shown in table below:

Parameter setting:	Alternator stator voltage (U-W):	VLT pot setting:	Explanation
[P100] = 380 [P139] = 30	380Vac rms		VLT POT set to mid position (0%)

(nominal stator voltage is set to 380Vac and pot range to ±15% of 380Vac)	320Vac rms		VLT pot set to MIN. position (-15%)
	440Vac rms		VLT pot set to MAX. position (+15%)

In the above example, AVR nominal regulation voltage level is set to 380 (Vac rms) and onboard VLT pot setting range is set to 30 (±15%). In this case, if the VLT pot position is set to MID position as shown in the table above (0% of nominal voltage set value), AVR will regulate the alternator voltage to 380Vac. Rotating the VLT pot to its minimum position (fully CCW) will reduce the alternator voltage down to 320Vac (-15% of nominal set value, set by parameter [P100]). Rotating the VLT pot to its maximum position (fully CW) will increase the alternator voltage to 440Vac (+15% of nominal set value). User can set the minimum and maximum voltage adjustment range by setting parameter [P139] according to their requirement.

4-2. EXTERNAL POT connection (E1 & E2 terminals):

DAVR20 allows controlling of the alternator voltage via an EXTERNAL POT, connected to the AVR unit. Connection is shown in figure below:

This pot can be mounted at a remote location to allow the user to “fine-tune” alternator voltage as required.

If the cable length exceeds 3m, it is recommended that a shielded cable is used, and the cable shield is connected to EARTH terminal near the AVR side only, opposite end of the shield should be left unconnected.

DAVR20 detects the external POT connection and user is required to set the “External Pot Effective Range” parameter: [P142] to suit their application.

In order to use EXT. POT connection, ensure that, AUX input is DISABLED from the program menu. An example of setting EXT. POT range to adjust ±15% of VLT pot setting below:

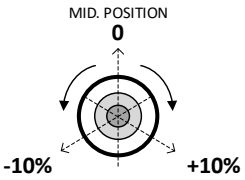
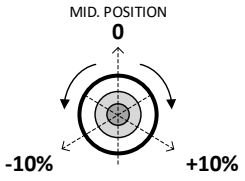
Parameter number	Parameter Description	Units	Min-Max Range	Explanation
[P123]	AUXILIARY input mode:	value	0 - 3	“0” = AUX input is DISABLED (EXT POT input is ENABLED)
				“1” = -5Vdc / 0 / +5Vdc input
				“3” = 0Vdc – 10Vdc input
[P142]	External Pot Effective Range:	%	0 - 30	Adjustment range: ±0% to ±15% of set nominal voltage value (factory default value: 30)

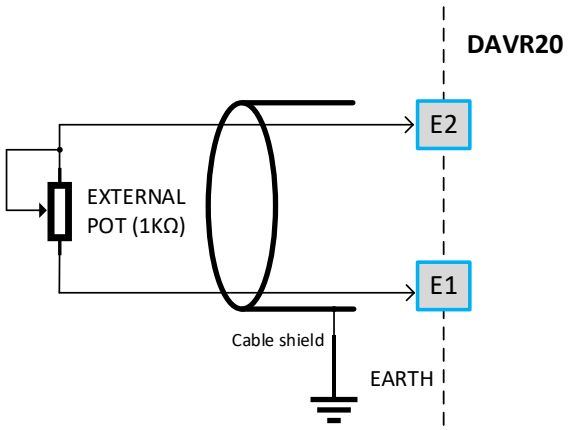
To enable the EXT POT control, [P123] should be set to “0” value. This parameter setting disables the “AUXILIARY” input and enables the “EXT POT” control input. Both “AUX” input and “EXT POT” input cannot be enabled at the same time, since both AUX and EXT POT acts on the same voltage setting reference value.

External pot acts on the voltage set value by VLT pot. In the example given below, the VLT pot is set to 400Vac rms and the External Pot maximum effective control range is set to ±10%

EXAMPLE:

Set EXTERNAL Pot adjustment range to ±10% for above shown example:

Parameter setting:	Alternator stator voltage (U-W):	VLT pot setting:	Explanation
[P100] = 380 [P139] = 30 [P123] = 0 [P142] = 20 (nominal stator voltage is set to 380Vac and external pot range to ±10% of 380Vac)	380Vac rms		VLT POT set to 380Vac rms
	340Vac rms		EXTERNAL Pot set to minimum
	420Vac rms		EXTERNAL Pot set to maximum



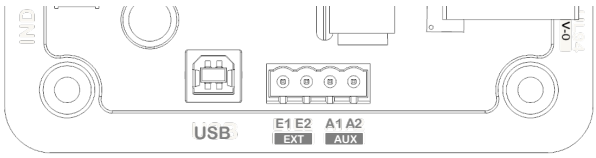
4-3. AUXILIARY Analogue Signal connection (A1 & A2 terminals):

DAVR20 is also equipped with an analogue AUX signal input terminal where an external device can control the alternator voltage via 0-10Vdc or ±5Vdc analogue signal, depending on the parameter selection in configuration software. By factory default, parameter “AUX Input Mode” [P123] is set to “DISABLED” mode, and the function is disabled. If AUXILIARY signal input function is going to be used, “AUX Input Mode” must be enabled. The mode selection for AUX input is explained in the table below:

Parameter number	Parameter Description	Parameter setting	Explanation	
[P123]	"AUX Input Mode"	0	"AUX Input Mode" function DISABLED	"EXT POT" function is **ENABLED**
		1	-5Vdc to +5Vdc analogue voltage signal input	"EXT POT" function is **DISABLED**
		3	0Vdc to +10Vdc analogue voltage signal input	

⚠	If [P123] = 0, then "AUX Input Mode" function is DISABLED and EXTERNAL POT input function is automatically ENABLED. Setting [P123] to any one of the other operating modes will automatically DISABLE the EXTERNAL POT control function. Both EXTERNAL POT and AUX input cannot be enabled at the same time, only the selected mode is allowed to operate at any time.

AUXILIARY Analogue signal connection terminals are marked as "A1" and "A2" on the AVR tray. Terminals are shown in figure below.

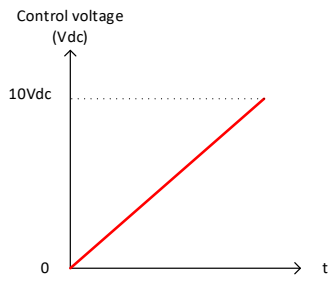
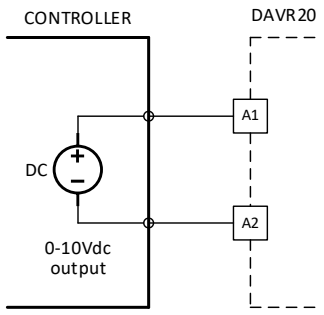


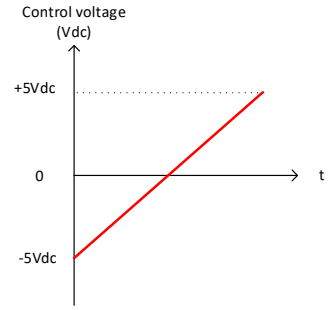
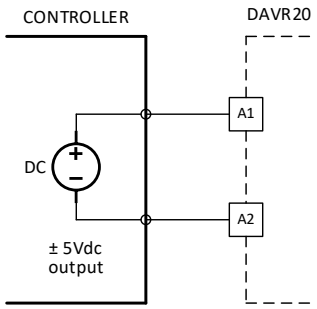
Ext. Pot input AUX input

For best performance, the cable pair connected to A1 and A2 should be twisted pair or shielded type and should be installed away from power cables. If shielded cable is used, connect only one end to the GND terminal at the instrument side.

Type of signal interface is selected by setting parameter [P123] as shown in table above. Remember that, if AUX input is ENABLED, EXT POT function is automatically DISABLED.

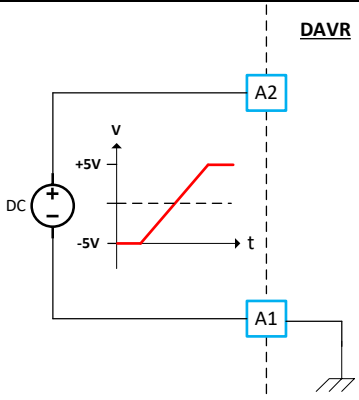
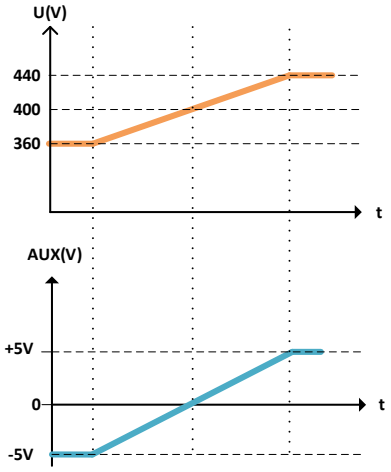
Remember that AUX inputs and COM port terminals are connected to the same common ground system. If AUX terminals connected to an external control unit, ensure that it is safely isolated while using COM port during live operation.

Function Description:	AUX input control characteristics:	Wiring diagram:
[P123] = 3 AUX Analogue control input connection for 0-10Vdc (Connected to an external control unit)	 AUX input analogue control voltage (0-10Vdc)	

[P123] = 1 AUX Analogue control input connection for -5Vdc 0 +5Vdc (Connected to an external control unit)	 AUX input analogue control voltage (-5Vdc 0 +5Vdc)	

4.4: AUX Signal control range:

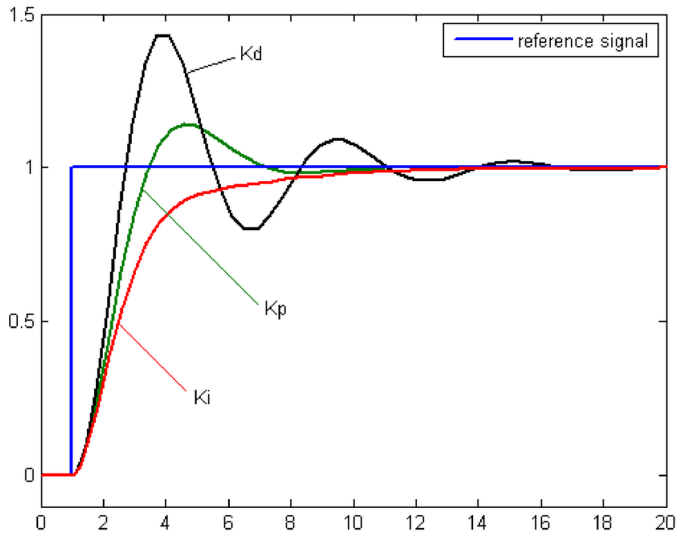
The effective control range of the AUX input signal is determined by parameter [P124]. This parameter defines the portion of the analogue signal, applied across terminals A1 and A2, that influences the set AVR voltage reference. Set as a percentage of the full input signal swing, parameter [P124] limits the control range and enables adjustment of the AVR set voltage in response to changes across the entire analogue signal scale applied across A1 and A2 terminals. Parameter explanation is shown in table below:

Parameter setting:	**Set value:**	**Connection & control characteristics:**	**Explanations:**
[P123]	1		DAVR20 "AUX" signal input characteristic is set to control over ±5Vdc analogue signal
[P124]	20		[P124] is set to control ±10% of the AVR voltage reference, over full-scale signal change across A1 & A2 signal terminals. Control characteristic is LINEAR over full analogue signal range.

5- Setting the "PID" parameters on DAVR20:

DAVR20 has extensive flexibility to set a stable voltage regulation on different alternator frame sizes and dynamic characteristics. The built-in PID control function can be set for optimum performance for any size alternator and load characteristics. Stability setting also allows the user to set optimum performance for voltage dip and rise during block load application to the generator set.

The stability pot on the AVR only controls the K_P gain of the PID control system during operation. The complementary integral (K_I) and differential (K_D) gains can be set using the parameter menu. Once correct K_P, K_I and K_D gains are set, then the proportional (K_P) gain can be further adjusted by the on-board trimmer on the AVR unit. User can set different K_P, K_I and K_D gains for each alternator frame size and can save these parameters under the specific alternator frame name, using the PC TOOL software. Therefore, for later use, user can recall the "Preset PID Gain Parameter" values from the menu, based on the alternator type.



PID values are set with parameters from the PC tool S/W as shown in the table below:

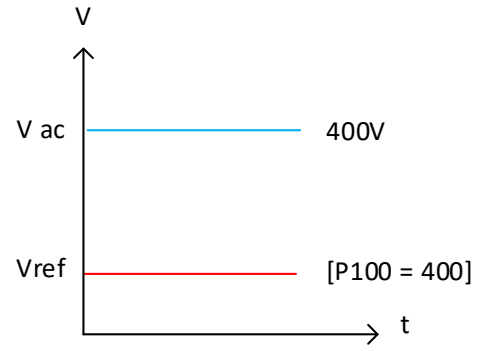
Parameter number	Parameter Description	Factory Default	Min-Max Setting value	Explanations
[P110]	"PID setting parameters"	425	0 - 2048	PROPORTIONAL "K_P" value. (Increasing the value will cause faster AVR response to step load change but may worsen steady-state stability)
[P111]		250		INTEGRAL "K_I" value. (increasing this value will improve steady-state stability but slow down the step load change response)
[P112]		125		DIFFERENTIAL "K_D" value. (increasing this value will improve dynamic response but may effect steady-state performance)

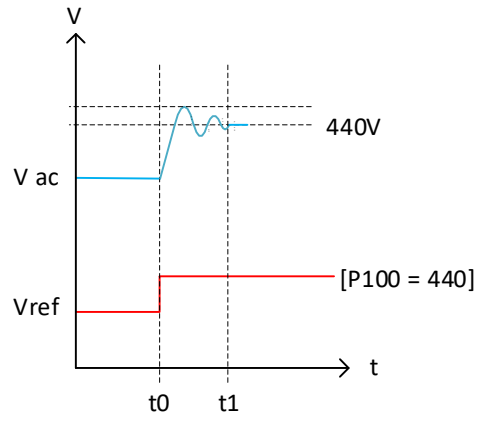
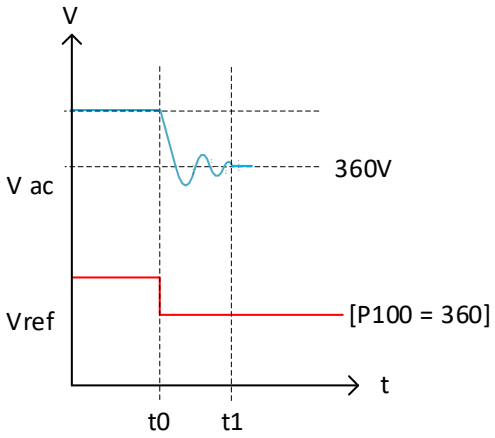
All ENKO Digital AVR units are programmed to “Factory Default” values and the default vales for PID settings are shown in the table above. User is expected to “fine-tune” the AVR model to according to their alternator frame dynamic characteristics. Once the optimum PID constants are determined and set for a particular alternator frame, user can save this file in the alternator’s type name for later use during production.

Setting the optimum PID values requires the best dynamic performance values of the alternator against a STEP change of its voltage reference setting. Initial K_P, K_I and K_D values setting procedure is explained in more detail below. Optimum PID values setting requires the minimum “Overshoot” and “Undershoot” values of the alternator voltage waveform under step load change and should fall within the required settling time duration. The alternator dynamic performance limits are explained in ISO8528 standard, based on G1, G2 and G3 performance class groups.

User should select a performance class as explained in ISO8528 standard and tune the AVR unit PID parameters to ensure that, AVR response characteristics best fits with the alternator dynamic characteristics to get the best overall performance for a step load change of the generator.

Follow the steps described below to optimise the PID parameters:

Step	Action:	Explanations:
1-	Connect DAVR20 to alternator according to your application	Refer to wiring configuration chapter of this document.
2-	Connect DAVR20 to PC via USB com port and observe factory set values for [P110], [P111] and [P112]	Refer to the PID parameter factory default section of the parameter list of this document. [P110]: K_P value, (default set to 425) [P111]: K_I value, (default set to 250) [P112]: K_D value, (default set to 125)
3-	Set generator voltage to your desired nominal stator voltage, using parameter [P100]	

4-	While monitoring the alternator stator voltage, set [P100] to approximately +10% above set voltage level		Must optimise the overshoot (+ΔV) and the settling time duration (t1 – t0) using Kp, Ki and Kd constants, using parameters [P110], [P111] and [P112]. For more detailed limits of the dynamic performance limits, refer to ISO8528 standard.
5-	Repeat the test for negative response by setting voltage reference parameter [P100] to -10% of set nominal voltage value.		

Notes on PID parameter settings:

All ENKO digital AVR units have factory set values programmed during production. These parameter values are based on common dynamic performance characteristics of brushless alternators of medium size ratings. These values may require to be tuned for best performance on specific alternator models and ratings.

Once the best performance PID values are set, user can save these values in a file to be used later for the same alternator frame size in future, therefore further tuning is not required during production.

While setting the PID values, both “Steady State” operation and “Step Change” dynamic performance must be tested. This ensures optimum overall performance with any alternator frame size.

5.1: Using “STB” trimmer on the AVR unit:

There is an integrated stability trimmer pot (STB pot) on the AVR unit, and this trimmer has a limited set range during operation to allow the user to trim the K_P value of the PID parameters, set by the configuration software. This only allows a limited trimming range to allow the user to fine-tune the steady-state regulation behaviour of the AVR. Main settings of PID parameters must be adjusted, using the configuration tool software and the AVR parameter set.

The STB trimmer effective setting range can also be set using parameter “P140]. By setting the value of this parameter, the effective adjustment range of the STABILITY trimmer pot and this is shown in the table below:

Parameter number	Parameter Description	Units	Parameter set limits	Explanation:
[P140]	"STB" Trimmer pot adjustment range	%	0 – 30 (Factory default value: 30)	Changes the value of K_P as % of the value set by parameter P110

5.2: Definition of K_P (Differential Coefficient) parameter:

K_P parameter value sets the "Proportional Gain" of the PID function of the AVR unit. This value must be set according to the steady-state voltage regulation ripple value and must satisfy the performance requirements set by the AVR specifications as closely as possible.

K_P parameter reacts to the present error by applying a correction value proportional to the deviation from the set reference point. Increasing the value of this coefficient can enhance the response time but can lead to overshoot and oscillations and too low values will reduce the system response to sudden actions. Therefore, when setting this value, take care to make sure that voltage regulation ripple is within the specified limits and response time is not too slow.

This coefficient value must be set in relation to **K_I** and **K_D** coefficient values, based on the required response of the alternator system.

5.3: Definition of K_I (Integral Coefficient) parameter:

K_I parameter value sets the "Integral Gain" of the PID system, which accumulates the past errors and applies corrections to eliminate the steady-state errors. Too high setting of this coefficient may cause instability in the system response to load changes on the alternator. Too low settings will reduce the capability of the system to correct errors completely but improves persistent oscillations in the system

This value also must be set according to the other PID parameters to get the best performance with sudden load changes on the alternator.

5.4: Definition of K_D (Differential Coefficient) parameter:

K_D Coefficient parameter is the derivative gain value and corrects the future trends of the load behaviour based on the rate of change of error. Increasing this value will eliminate the overshoot and dampen the system but excessive values will amplify noise components in the response characteristics.

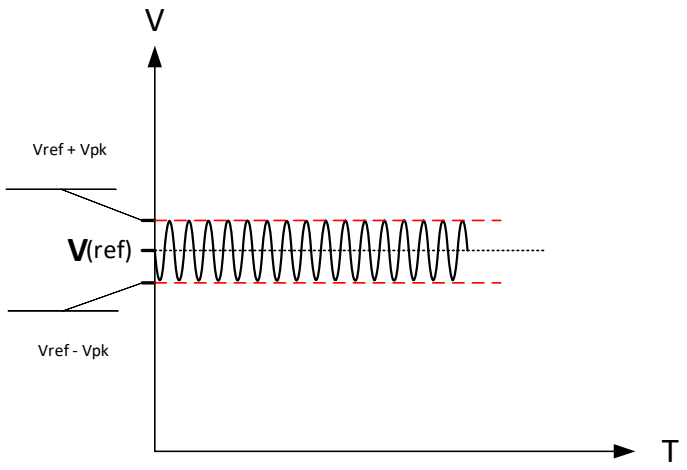
Low value settings will reduce the system response time to sudden load changes on the alternator. The value of differential coefficient must be set together with the integral and proportional coefficient values to get the best performance characteristics.

As a practical approach, PID settings can be done as follows:

1. Set K_I and K_D to a low level and slowly increase K_P coefficient value until the voltage regulation starts to oscillate,
2. Then start increasing K_I to eliminate the voltage ripple to get smooth voltage regulation on the alternator output,
3. Then introduce K_D to get best performance with step load change,
4. Repeat the value settings to make sure that best dynamic performance is achieved under all operating conditions,
5. Use factory settings for PID values for DAVR20 to start fine tuning the values to get best dynamic performance with the alternator,

5.5: Steady State Voltage Regulation:

Although PID coefficients set the performance for the “Dynamic Performance” of the AVR and the Alternator, care must also be taken when setting the “Steady-State” voltage regulation and the “Voltage Ripple” with no-load conditions. User must set the PID gain values in order to get the best “steady state” voltage regulation as stated in the AVR technical specifications document. “Steady-State” voltage regulation defined in the table below:

Parameter Description	Units	Function Description	Explanation:
Steady-State Voltage Regulation	%		V(ref) ±0.5% (specified ripple factor)

As an example, if stator voltage reference value is set to 400Vac, then the AVR can achieve a steady-state voltage regulation with a ripple factor, less than ±2Vpk.

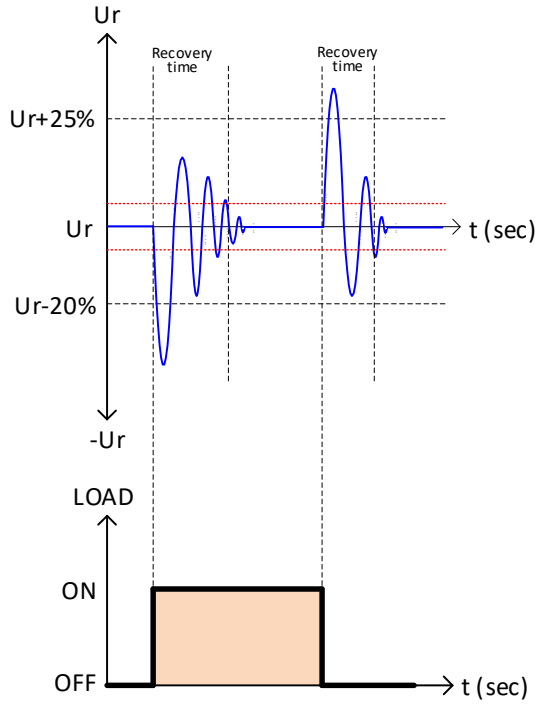
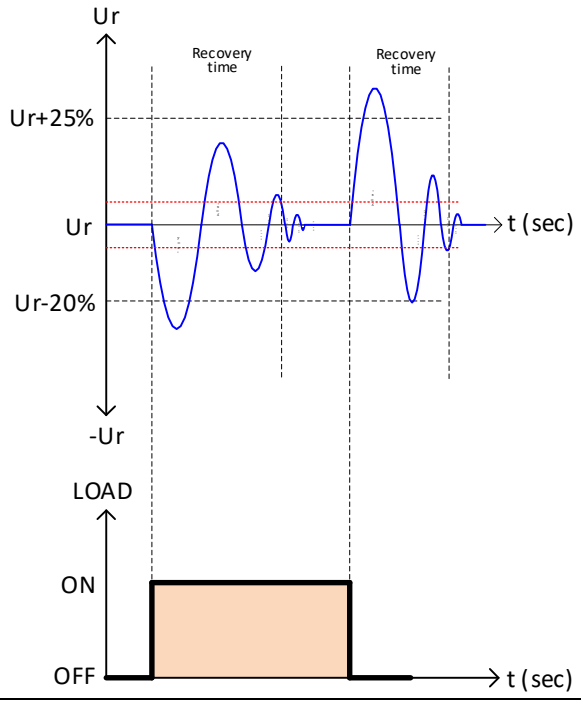
5.6: Reference Change “Ramp Limit” function:

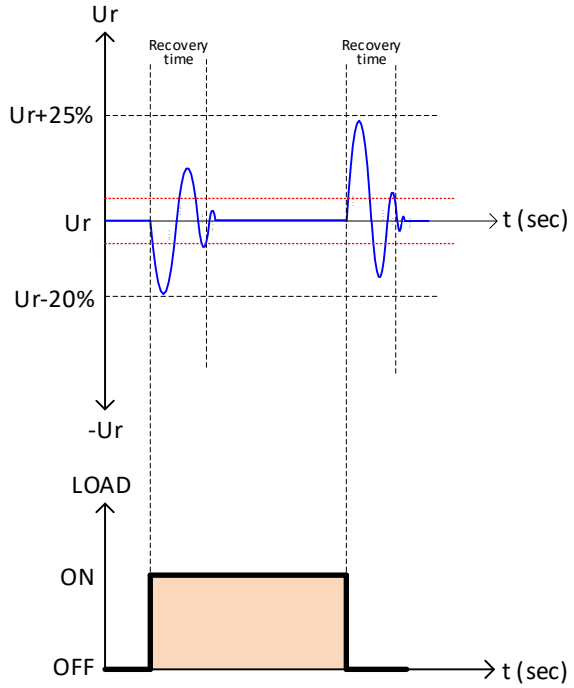
When changing the voltage reference either from software or using VLT pot on the AVR or using the EXTERNAL Pot, it is possible to smooth the “Voltage change Response” with respect to the unit change in reference regulation voltage value so that, the alternator stator voltage has smooth and slightly delayed control to avoid any unwanted fluctuations due to setting inconsistency. It is possible to set this with parameter number “P107” and function description is explained in the table below:

Parameter number	Parameter Description	Units	Parameter set limits	Explanation:
[P107]	Reference Change RAMP limit function	V/s	0 - 100	Sets some time delay while changing the voltage reference value of the AVR
			50	Factory default setting

5.7: Dynamic behaviour of AVR based on PID settings:

By carefully setting the PID parameter values, it is possible to adopt the AVR to perform under any operating conditions with a wide range of alternator frame sizes. The effects of P, I and D coefficient settings of the AVR unit is described in basic terms in the following table:

K_P, K_I and K_D coefficients	ALTERNATOR RESPONSE
AVR PID settings "Under-damped": K_P and K_D coefficients set too high, K_I coefficient set too low! (Step load response is under-damped, and ringing is high, transient peaks are high)	
AVR PID settings "Over-damped": K_I coefficient is set too high and K_D and K_P coefficients are set too low! (Step load response is Over-damped, and ringing is moderate, transient peaks are within limits, but recovery time is too long)	

AVR PID Parameters set correctly: K_P K_I and K_D coefficients set correctly, (Transients are within operational limits, recovery time is according to G1, G2 or G3 operating limits)	

5.8: Management of set PID parameters:

DAVR20 requires PID parameters settings for any specific alternator model based on alternator design parameters and their dynamic transient response characteristics. Once best PID settings are determined, the parameter set can be saved and automatically recalled for future applications.

PC Configuration software allows the user to save the parameter sets for any specific alternator frame size and can be recalled for automatic download during production phase. This means that; PID parameter tuning is to be set only for once per different alternator type and recalled for future use.

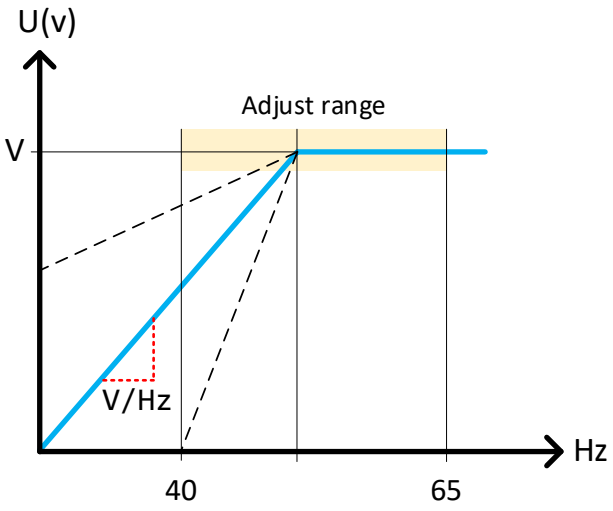
6- "LOAD ACCEPTANCE" parameter settings:

DAVR20 has excellent algorithms to allow high performance during operation in a genset configuration. Based on the engine response time and characteristics with high "Block Load" application, DAVR20 behaviour can be set to ease the burden on the diesel engine and at the same time, control the alternator excitation drive to ensure excellent performance characteristics for demanding applications.

By setting the parameters carefully, it is possible to down-size the prime mover to handle high-capacity sudden load applications and yet stay within ISO8528 standard operating limits.

6.1: Setting UFRO parameters:

To protect alternator excitation system, based on the speed of the prime mover, DAVR20 unit can be configured to reduce the excitation drive of the alternator, hence reduce the stator voltage to prevent over-excitation of the alternator. Two parameters are available to set the frequency roll-off point and the slope of the voltage reduction with respect to the frequency. These two parameters are [P117] and [P118] respectively. Parameter settings are explained in the table below:

Parameter number	Parameter Description	Set limits	Explanation:
[P117]	UFRO Knee Point (Hz)	40 – 65 Default is 48Hz	
[P118]	DIP Rate (V/Hz)	0 – 80 Default is 8V/Hz	

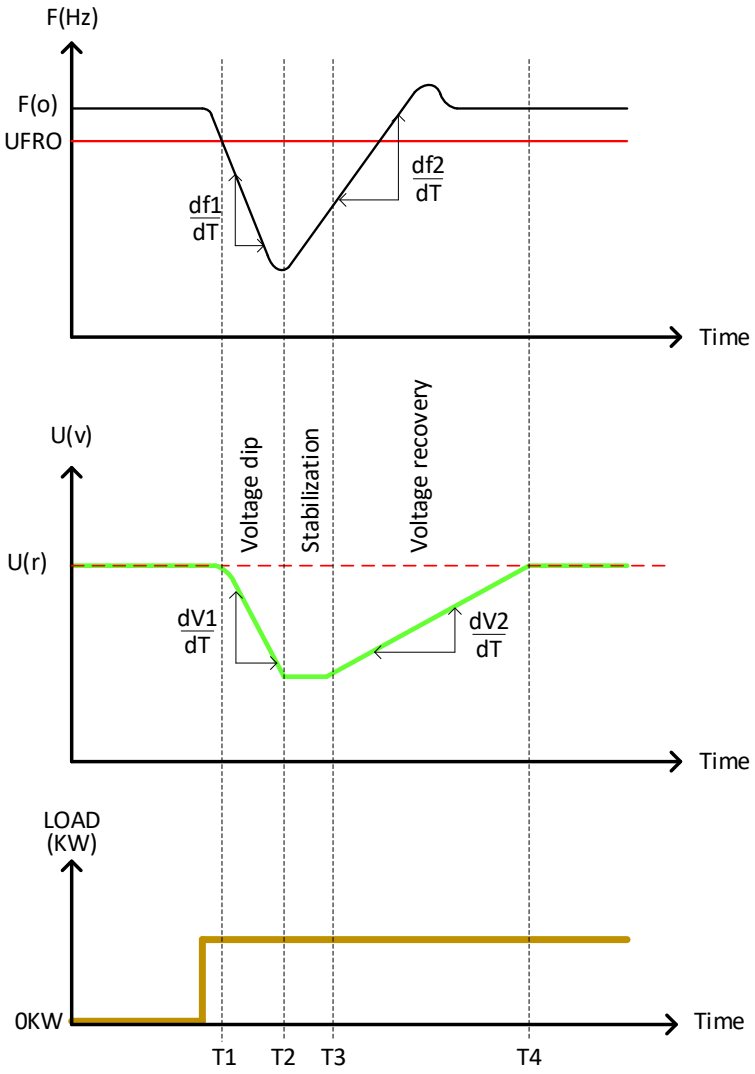
The slope parameter [P118] sets the rate of voltage reduction per hertz drop in frequency. This parameter setting also effects the behaviour of the alternator when recovering from a DIP condition and this is also part of "Load Acceptance" function (LAM) configuration. Therefore, setting the negative voltage slope with respect to frequency will also affect how the system will recover from a sudden load state.

The V/Hz parameter indirectly sets the excitation current of the alternator to maintain safe limits to how much current is injected to the field winding. Users must select the parameter value carefully to ensure that overall system performance is according to their expected behaviour.

6.2: Setting "Load Acceptance" parameters (LAM):

LAM function is designed to increase the recovery capacity of the generator when a sudden block load is applied to the generator output. LAM function acts upon the frequency variance of the generator with sudden high load application and accurately adjusts the AVR voltage set point to allow the generator to recover from its high dynamic stress status.

LAM function adjust trimmer pot on the AVR unit allows the user to set the behaviour of the generator, according to the required sudden block load recovery capability of the overall system. LAM function is a complex function, and it covers the whole period, from sudden load application to complete recovery of the generator system. LAM function is simply illustrated below:

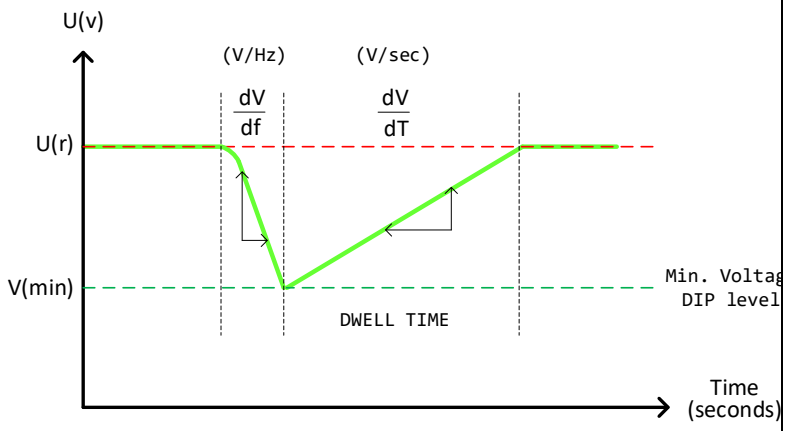


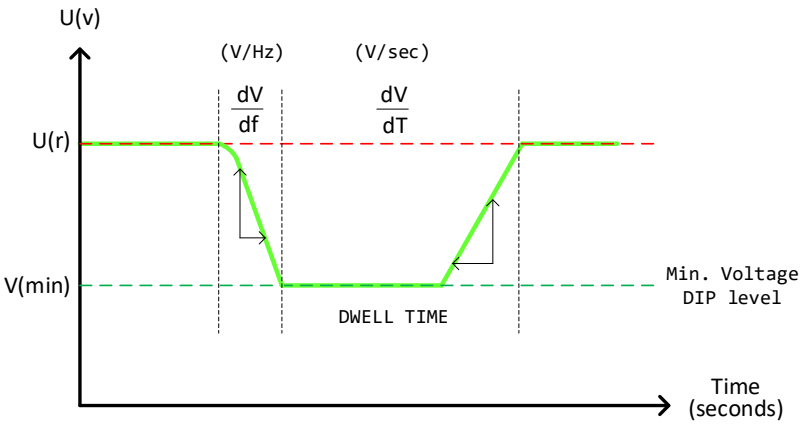
Setting [P118] = 0 will cancel the function, means that there will be no voltage reduction when block load is applied to the generator. When load is applied to the generator output, AVR will try to keep the alternator voltage according to the set regulation level. In applications where there will be no sudden high load applications to the generator, this option may be preferred to ensure stiff voltage regulation against load variations based on the load capacity and diesel limits.

6.2.1: Setting DWELL parameters:

To set the recovery characteristics following a voltage DIP condition, it is required to set the time the voltage rises back to its nominal set voltage regulation reference value. In other words, the slope of recovery characteristics must also be set before the generator can return to its normal operating conditions.

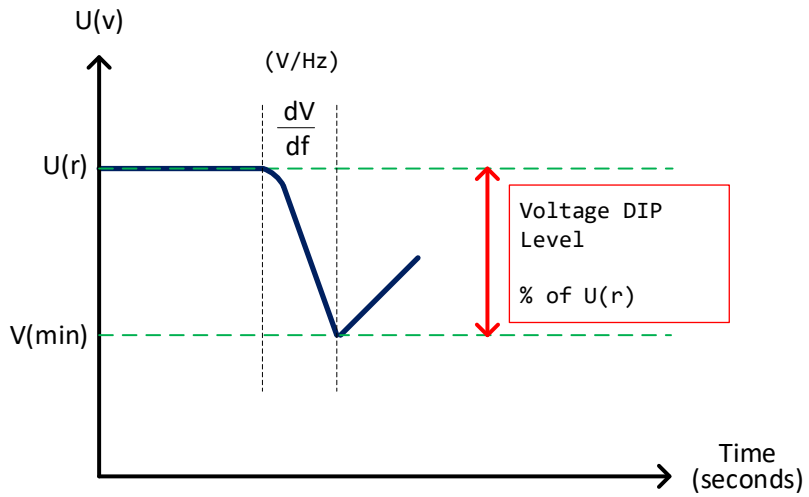
To set this characteristic, parameter [P119] (DWELL time) is used. This parameter is also further enhanced with parameter "[P120]" (LAM Mode Selection), which selects the type of recovery characteristics from a DIP state. DAVR20 allows two different recovery characteristics, which can be set by parameter [P120], and the detailed operation is shown in table below:

Parameter number	Parameter Description	Set limits	Explanation:
[P119]	DWELL Time setting (+dV/dT) V/sec	0 - 480	
[P120]	LAM Mode Selection (No-DELAY)	[P120] = 0 (Normal mode)	

Parameter number	Parameter Description	Set limits	Explanation:
[P119]	DWELL Time setting (+dV/dT) V/sec	0 - 480	
[P120]	LAM Mode Selection (DELAY)	P120 = 1 (Enhanced mode)	

6.2.2: Setting Minimum Voltage Reference Percentage:

During LAM parameter settings, if user is going to comply to ISO8528 standards for operating limits, the minimum voltage DIP level is required to be set according to the “G” performance class and in this case the minimum voltage DIP level needs to be also controlled and set by the parameter configuration menu. To set the minimum voltage DIP level, parameter “P109” needs to be configured. The parameter details are explained in the table below:

Parameter number	Parameter Description	Set limits	Explanation:
[P109]	Minimum Voltage Reference percentage (% of U(r))	0 - 100	

In the example above, Voltage Regulation reference is set to 400Vac (alternator is generating 400Vac) and if “[P109] = 50”, it will allow the voltage DIP to limit at 50% of 400Vac, which is 200Vac. In this case, DAVR20 will try to maintain the DIP voltage level at 200Vac even if the frequency drop exceeds the “DIP Rate” determined voltage level.

7- AVR "START SEQUENCE" Control:

DAVR20 Voltage Regulator unit is designed with comprehensive "START CONTROL" functions and can be tailored to fit all demanding applications.

The DAVR's starting procedure in AVR mode can be configured using the "Starting Frequency" and "Starting Time Delay" parameters. The "Starting Frequency" defines the minimum generator frequency at which the DAVR begins regulating voltage. Once this frequency is reached, the "Starting Time Delay" parameter determines the additional waiting time before the DAVR activates field excitation.

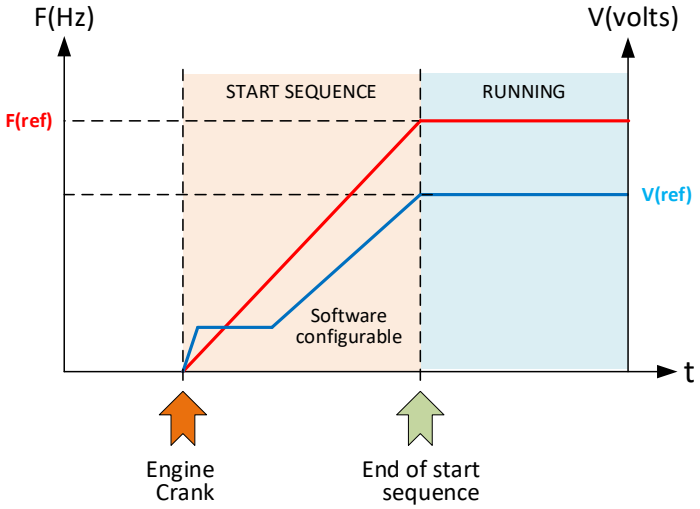
The "Starting Frequency" is measured from the sense input terminals and ensures that the generator reaches a stable operating speed before voltage regulation begins. The "Starting Time Delay" allows further control by introducing a controlled delay after the frequency threshold is met. This delay can be useful for synchronizing multiple gensets in parallel operation or for delaying the application of load to the generator. Proper configuration of these parameters helps prevent premature excitation and ensures a smooth startup sequence.

START sequence has the following control zones, which can be configured via PC-Tools SW menu. The AVR unit will drive the excitation (voltage regulation) based on the conditions set by the user. The following start sequence features can be set:

1. Frequency (rpm) dependent start delay,
2. Time dependent start delay,
3. Ramp fitted start sequence,
4. "Start" control from menu parameter set,
5. "Start control" via an external signal,

The above start-sequence parameters should be set by the user to define the start characteristics of the alternator, based on the operation of the prime mover. The alternator residual voltage seen across the P1 and P2 power input terminals must be at least 6Vac to automatically start the voltage build-up on the alternator stator windings. If the residual voltage is below 6Vac, the AVR may not have sufficient energy to start excitation. In this case, the excitation winding needs to be briefly flashed with a 9V battery, connected with the correct polarity to the F- and F+ terminals.

A graphical representation of the start sequence functions is shown in figure below:



As graphically shown above, the START SEQUENCE of the AVR must be configured to suit the required application. The sequence starts with the engine cranking and ends with the user determined condition, where normal AVR mode operation (normal voltage regulation) starts. This can vary from a few milliseconds to almost 2 hours (7200 seconds) which can fit for almost any demand in the field.

In addition to the configurable "Start Sequence" features, the AVR operation can be put in "HALT" condition by activating one of the configurable digital inputs. This feature, together with the "Start Sequence" features make

DAVR20 AVR unit suitable for special applications, where the prime mover cannot start immediately like the classic diesel engines.

“Start Sequence” can also be activated via “External Start” control input, which is described further in this user manual. If “Start Sequence” parameters are set according to user requirement, AVR will start operation with set start pattern, after receiving the “External Start” signal from one of its programmed digital inputs.

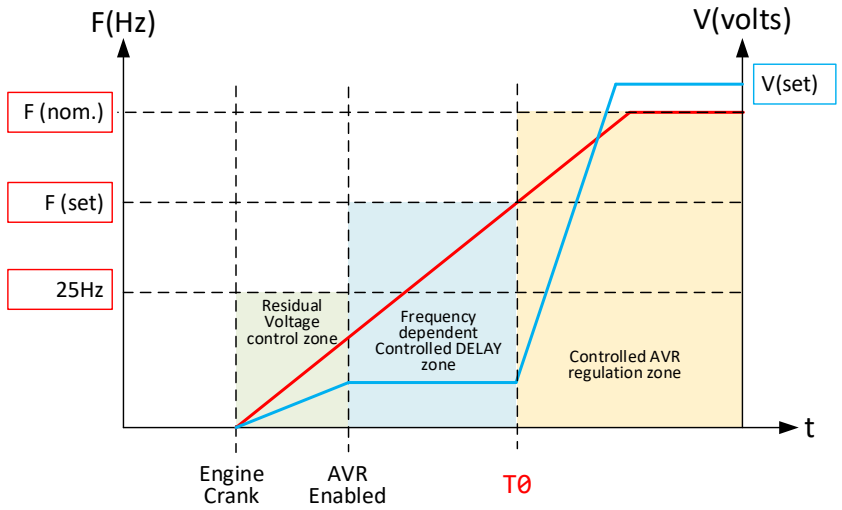
The “START SEQUENCE” features are described in more detail below:

7.1: “Starting Frequency” Delay function:

DAVR20 operation can be delayed until the prime mover reaches a predetermined speed (alternator frequency sensed across the sensing terminals) level and at this instant, AVR will check other linked “Start Sequence” parameters and control the alternator excitation accordingly.

The DAVR's starting procedure in AVR mode can be configured using the “Starting Frequency” and “Starting Delay” parameters. The Starting Frequency defines the minimum generator frequency at which the DAVR begins regulating voltage. Once this frequency is reached, the Starting Delay parameter determines the additional waiting time before the DAVR activates field excitation.

“START FREQUENCY DELAY” function is set with the parameter number [P105], and the function is described in more detail in the following table:

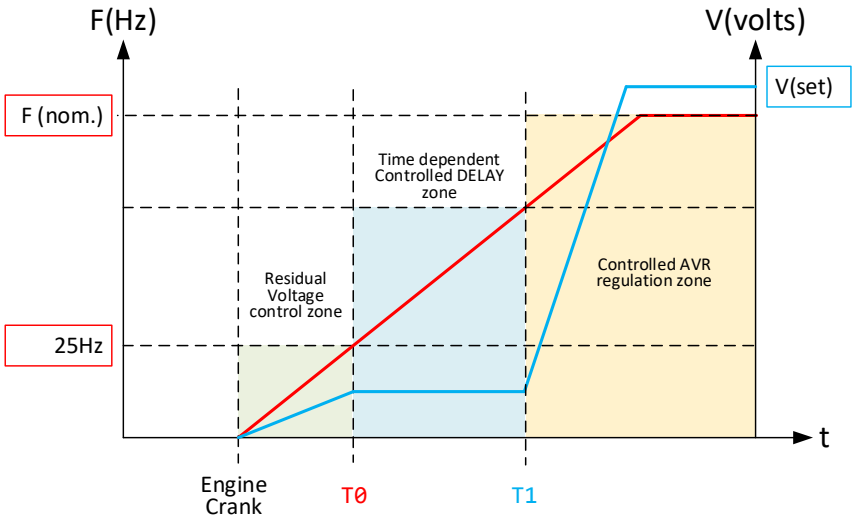
Parameter Number	Parameter Description	Setting limits	Graphical presentation:
[P105]	START FREQUENCY Delay control function	25 - 75 (Hertz) Default is 25Hz	

Until the start frequency is reached (25Hz minimum), AVR will regulate the alternator voltage at around 60Vac to maintain its own power to the AVR hardware. If the residual voltage level of the alternator is higher than this level, the AVR will operate at this residual voltage level, until the start sequence begins. A minimum of 6Vac across P1 and P2 is required to start the AVR control. If this voltage level is not reached during start of the operation, AVR may not be able to start controlling its excitation drive function.

AVR STARTING control parameters are used in combination with each other and must be set according to the application requirements. The following START CONTROL parameters should be set together to control the AVR as per application requirements.

7.2: "Start Time Delay" Function:

Once the "START FREQUENCY" limit is reached, AVR will check the START TIME Delay period and control the AVR excitation function according to its set parameter values. "START TIME Delay" function and its related parameter settings explained in more detail in the table below:

Parameter Number	Parameter Description	Set limits	Graphical presentation:
[P104]	AVR START TIME Delay function	0-7200 (seconds) Default is 0s	

"START TIME Delay" value is set by parameter [P104] and can be adjusted between 0 sec. to 7200 sec. time duration. The timing will start at (T0) after the "START FREQUENCY" value is reached by the prime mover. Until the end of start delay time, DAVR20 will regulate the alternator phase voltage at around 60Vac. This is required to maintain power to its own hardware circuit inside the AVR. If the residual voltage is higher than this value at the prime mover's "IDLE" or "RUNNING" speed (prime mover speed can be set to any level during this period, provided that, it is running at its nominal speed before the "Start Delay" time T1 is ended), this will not affect the normal operation of the AVR unit.

During "Start Delay" period, AVR will not start "Excitation" and wait at REST condition, until the end of the "Start Delay" period. At the end of this controlled delay time, if the prime mover has exceeded the minimum operating frequency level (25Hz) and if the operating frequency is equal or more than the "Start Frequency" value, controlled excitation will start and set voltage regulation will be reached.

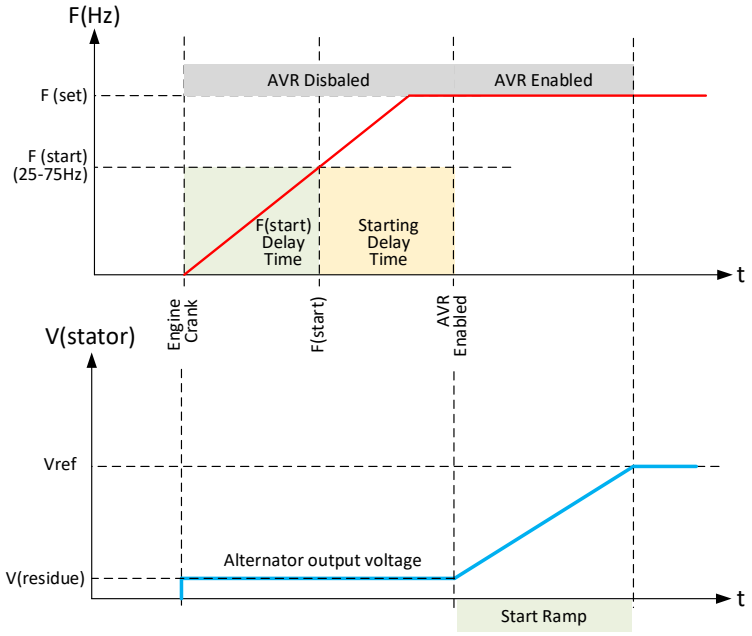
7.3: "Soft Start Ramp" Function:

The Startup Voltage Ramp is a controlled voltage increase phase that begins after the Starting Frequency and Starting Delay conditions are met. Once the delay time has elapsed, the DAVR gradually increases the output voltage toward the configured set voltage using a ramp rate defined in volts per second (V/S).

This controlled ramping prevents sudden voltage surges, reducing stress on the alternator and/or generator connected loads, and power system components. It ensures a smooth and stable transition to the operating voltage, minimizing inrush currents and mechanical strain on the generator. Proper configuration of the Startup Voltage Ramp is essential for optimizing startup behaviour, especially when operating in parallel with other generators or supplying sensitive loads.

"SOFT START RAMP" delay function checks that both set starting frequency conditions are satisfied and, also the "START DELAY" time has already elapsed, following these two conditions the AVR will act according to the set value

of “SOFT START RAMP” parameter. The related parameter number is “P106” and can be set between 0 to 7200 seconds. The parameter and its function are explained in more detail in the table below:

Parameter Number	Parameter Description	Setting limits	Graphical presentation:
[P106]	SOFT-START Ramp function	1 - 7200 (Seconds) (Default is 1)	

7.4: “Auto-Start” Enable/Disable:

DAVR20 has a control parameter to force the excitation function to be ENABLED or DISABLED. This parameter is [P102] and can START or STOP the AVR to operate. Detailed parameter description is given in the table below:

Parameter Number	Parameter Description	Setting limits	Explanations:
[P102]	AVR AUTO-START control parameter	[P102] = 0 (Disabled) Default setting	AVR in “HALT” state,
		[P102] = 1 (Enabled)	AVR in “RUN” mode (if the generator is running and there are no alarm conditions)

User can set this parameter such that, AVR function can start automatically, once the “Start Sequence” conditions are fulfilled and there are no active ALARM conditions. If the parameter is set to “0”, AVR will remain in HALT state, even if the generator is running. This feature is particularly useful, when testing specific operations on the generator. The parameter can be set via PC Tool software while the generator is running.

7.5: Manual "Start/Stop Control" with ALARM status flag parameter:

It is possible to "START" or "STOP" the AVR functioning manually, by setting parameter "[P101]" from the PC-Tools menu. This parameter also indicates if there has been an automatic HALT due to an alarm state of the AVR. Parameter function is described in the table below:

Parameter Number	Parameter Description	Setting limits	Explanations:
[P101]	AVR START status control parameter	[P101] = 0 (STOP) Default setting	AVR in "HALT" state. If set manually, it overrides all other START commands on the AVR. If there is an ALARM condition during normal operation, this flag is set to "0" automatically and needs to be set manually, or AVR power must be RESET.
		[P101] = 1 (START enable)	AVR in "RUN" mode (if the alternator is running and there are no alarm conditions) This parameter can be set manually from the menu to START or STOP the AVR functions manually during testing.

This parameter has also a "FLAG" action and automatically sets to "0" if there is an "active alarm" condition. Setting this parameter to "1" manually will enable normal operating of the AVR but if there is an active alarm condition, "[P101]" automatically sets back to "0" internally.

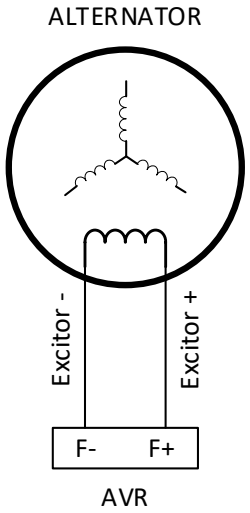
8- "Field Winding" connection (Alternator EXCITATION):

DAVR20 is designed to start automatically from residual stator voltage at start-up phase. Residual magnetism on the rotor excites a small residual voltage on the alternator stator windings and AVR unit can start the excitation process from this low residual voltage.

Minimum required residual voltage is 6VAC (rms) across the point of power connections (P1 and P2 terminals) of the AVR unit. Notice that if STAR- SERIES connection is used and power to the AVR is fed from the mid-winding terminals, minimum 6VAC is required between these terminals.

Alternator voltage will start to build-up as the engine rpm starts to increase, and regulation process will start approximately around 20Hz (600rpm for a 1500rpm generator system). FIELD winding connection is polarity sensitive and when connecting the field terminals, user must ensure correct polarity connection is made.

Connection schematic is shown below:



	If the AVR does not start automatically when the prime mover starts, it is advised to control the residual voltage across the power input terminals of the AVR unit. If it is low, then the field winding needs to be flashed, using a 9Vdc battery. Make sure that the battery connection polarity and the field polarity is correctly placed before flashing the field winding.

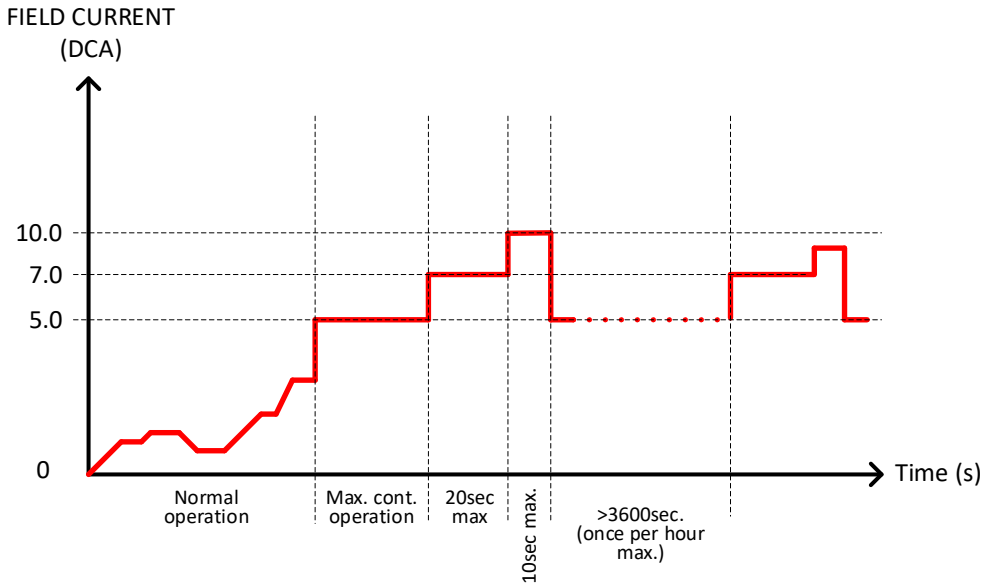
If SHUNT power connection configuration is selected, make sure that the voltage limit is not exceeded across the power terminals of the AVR, P1 and P2.

DAVR20 is fitted with SCR controlled drive for EXCITATION and can deliver 5.0Adc continuous under all operating conditions. For limited time duration, the AVR can deliver 7.0Adc (120 seconds) and 10Adc (10 seconds) into the FIELD winding at maximum operating temperature conditions. It is required that, the AVR is mounted such that the air around the AVR heatsink is freely ventilated.

For proper mounting conditions of the AVR, please refer to the "Mechanical Installation" chapter of this manual.

8.1 FIELD drive current:

DAVR20 has a continuous FIELD drive capacity of 5A, and user must select the correct model according to their application requirements. Field drive capacities are shown in table below:

DAVR20 is designed for 5.0Adc continuous operation. Momentary high-drive states are shown in the graphics. Notice that; after high-current drive state, FIELD current must reduce to continuous drive current value and next high-drive state cannot occur before **3600 seconds**, this is necessary for the AVR to cool down, before next high-drive state can be handled.	

	For reliable operation of the AVR unit, the specified limits of the AVR should not be exceeded. Excitation drive limit data is given as a guidance only and operating conditions may change these limits. It is always recommended that, AVR mount location is well ventilated and there is enough room for free air flow during operation. Also, it is a good practice not to mount the AVR very close to heat radiating elements.

	Alternator "Excitation" winding characteristics MUST be considered to determine the maximum limits of the system with the AVR. AVR limits do not guarantee a safe operation condition for the "Excitation" winding of the alternator. When configuring the AVR limits, user MUST also consider the limits of the alternator windings at the same time.

FIELD Overexcitation function is designed to calculate the thermal build-up energy in the FIELD winding and the function is based on the IDMT operation curve characteristics of fuse operation. In this function, the AVR measures the magnitude of the Excitation current and integrates this value against the time parameter and based on the mathematical model built into the AVR unit, the approximate Excitation temperature is calculated and OVEREXCITATION protection function acts upon the outcome of this calculation.

If correctly set, this function can protect the alternator winding limit conditions based on the alternator loading and the excitation current pattern. This function can be configured via PC-Tools software menu.

8.2: "Safe-Operating-Area" (SOA) curve of Excitation Output:

DAVR20 can deliver full rated excitation current over its entire operating temperature range. There are "built-in" protection functions to prevent the AVR and the alternator field winding being damaged during overexcitation conditions and these are explained in detail in this manual.

Apart from the "built-in" protection functions (can be configured by the user), there is also thermal limitation by design of the DAVR20, which the user must consider during operation or installation of the AVR in their application. If there is limited air circulation in the location where the AVR is fitted, user MUST ensure that, the AVR always stays within the "Safe-Operating-Area" curve, given in detail below:

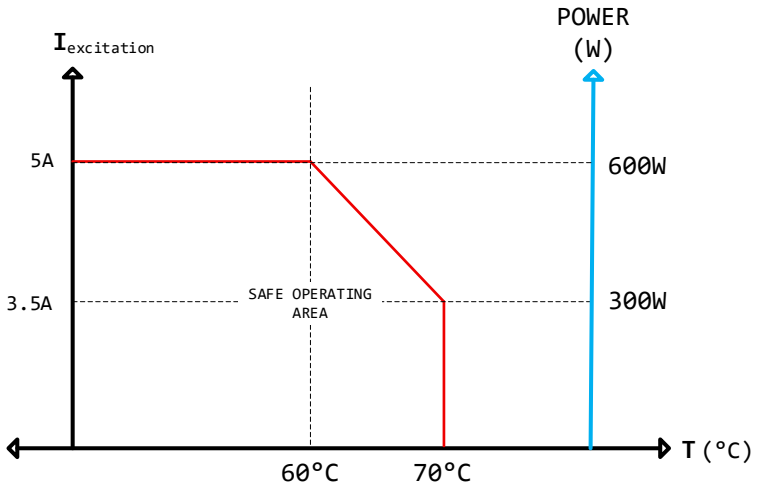


Figure 3: Safe Operating Area (SOA) for DAVR20

In the above SOA diagram, temperature axis is the temperature of the AVR's operating environment. If the AVR is mounted in an enclosed environment, where there is no free air movement for convection, the self-heating effect of the AVR can also increase the environment temperature within the enclosure. The self-heating effect of the AVR will increase the temperature of its environment above the outside temperature.

Therefore, when installing the AVR, ensure that the installed area has free air movement and under all conditions, the operating conditions of the AVR (considering the continuous excitation current and the AVR's environment temperature) stays within the given limits in the above SOA diagram.

Since SOA limits are not strictly controlled by the AVR, user must ensure the proper operating conditions for the AVR under all operating conditions of the generator.

8.3: POWER limitation of Excitation Output:

Although DAVR20 can deliver 5A continuous Excitation Current into the FIELD winding, based on the AVR power input voltage and the FIELD winding impedance, total power dissipation of the drive stage can increase above the limits of the cooling capacity of the heatsink. Therefore, under any condition, total Excitation Power delivered into the FIELD winding cannot exceed **600W,** which should be considered during installation. The limit should be calculated according to the formula indicated below:

$$P_{EXCITATION}(W) = (I_{FIELD})^2 \times R_{FIELD} <= 600W_{MAX}$$

The above power limit is valid up to 60°C ambient temperature and should be derated by -5%/°C above 60°C ambient conditions, reducing by 50% at an ambient temperature of 70°C. Above this temperature limit, AVR will be stressed above its design capacity.

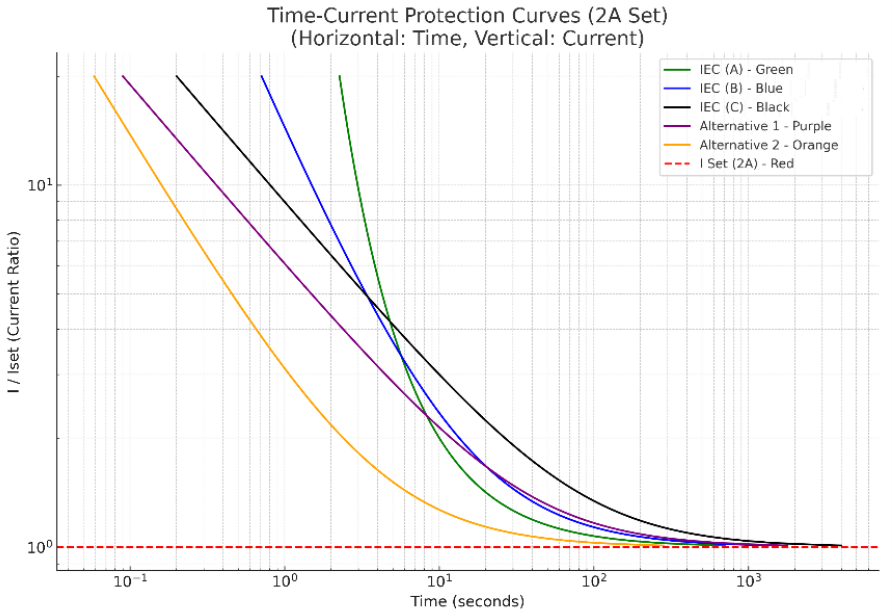
8.4: IDMT curve Protection for Excitation:

OEX protection function is based on IDMT curve fitting technique. This feature operates together with the OEX protection function and cannot be disabled. The “Excitation Current” into the FIELD winding is precisely calculated and fitted with the IDMT curve type **“IEC Standard Inverse Curve-A”**. With this method, DAVR20 precisely calculates the thermal load on the alternator winding and protects the winding and the drive stage of the AVR.

IDMT curve calculation is executed according to the formula given below:

$$x = T.(k/(y/I) \propto -1)$$

The standard curves are shown below for reference and DAVR is fitted with the IEC (A) curve characteristics and cannot be changed or disabled by the user.

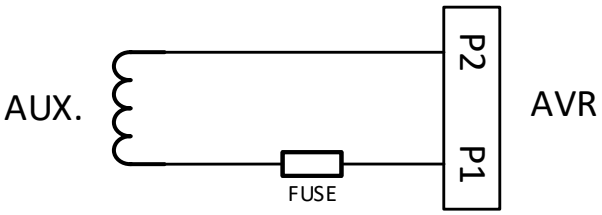
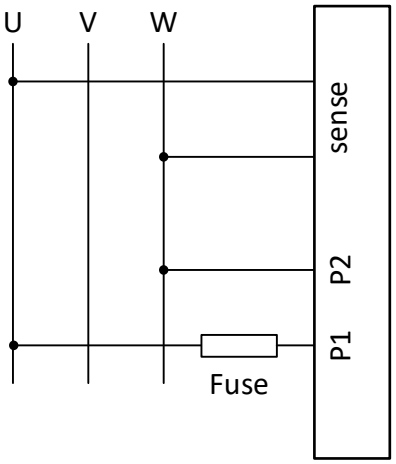
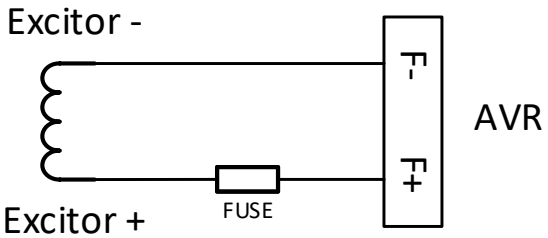


Line colour	Curve	T	k	∝
Green	IEC Standard Inverse curve A	1	0.140	0.02
Blue	IEC very Inverse curve B	1	13.5	1
Black	IEC Extremely Inverse curve C	1	80	2
Purple	Alternative curve A	0.449	80	2
Orange	Alternative curve B	28.57	0.140	1.4142

Based on the EXCITATION current demand by the alternator, thermal model of the switching power stage of the AVR is continuously iterated and protection is activated based on the OEX parameter settings, which are described in more detailed in the protection functions section of this user manual. The IDMT curve calculation is based on the “OEX Threshold Current Limit” value set by the user. The maximum limit cannot be changed, and it is fixed in the firmware of the AVR control software.

8.5 Fuse protection:

DAVR20 has no “on-board” integrated protection fuses, and all required fuses MUST be fitted externally. External fuse protection must be selected according to the regional standards compliance requirements, and they are intentionally not fitted on to the AVR unit.

AVR FUSE rating (must be used externally)	FUSE connection schematics
6,3A (quick blow type fuse) AUX winding connected protection	
6,3A (quick blow type fuse) SHUNT connected protection	
10A (quick blow type fuse) DC FIELD protection	

To comply to UL safety standards, a suitable fuse protection is required in the cable harness. A suitable fuse protection MUST be used with DAVR20 in all applications. In some applications, it is also required to use a separate fuse for the sensing inputs, and this regulation must be checked and fulfilled by the user.

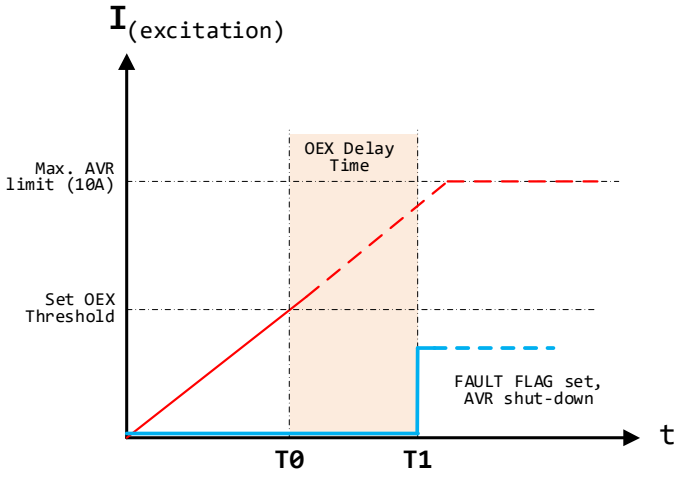
9- AVR Protection Functions:

DVAR20 is designed with a range of protection functions to protect the alternator and the load. A list of all protection functions are given in the table below. User can set and edit related parameters of these protection functions according to their applications. Each protection function operation is explained in their respective chapters below.

PROTECTION ALARM	Programmable Actions for Alarm functions	Setting limits	Explanation:
OVER EXCITATION	1. Trigger threshold 2. Trigger delay time 3. FAULT rip flag	Determined in the PCTools Software	All alarm states are explained in the related chapter of this user manual
LOSS OF SENSE			
GENERATOR OVER-VOLTAGE			
GENERATOR UNDER-VOLTAGE			
EXTERNAL POT DISCONNECT			
AVR TEMPERATURE			

9.1 OEX (Over Excitation) function:

"Over-Excitation Protection" function monitors the excitation current magnitude and triggers an internal delay timer. If the OEX current magnitude stays above the trigger threshold level, the alarm will trigger after the delay time register reaches its set value. The function details are shown in the table below:

Parameter Number	Parameter Description	Units	Parameter Limits	Explanations:
[P400]	OEX Threshold	mA.	0 – 10000 Default is 5000	
[P402]	OEX Delay time	Sec.	0 – 10 Default:30	

As described above, DAVR20 allows two stage OEX protection for the alternator:

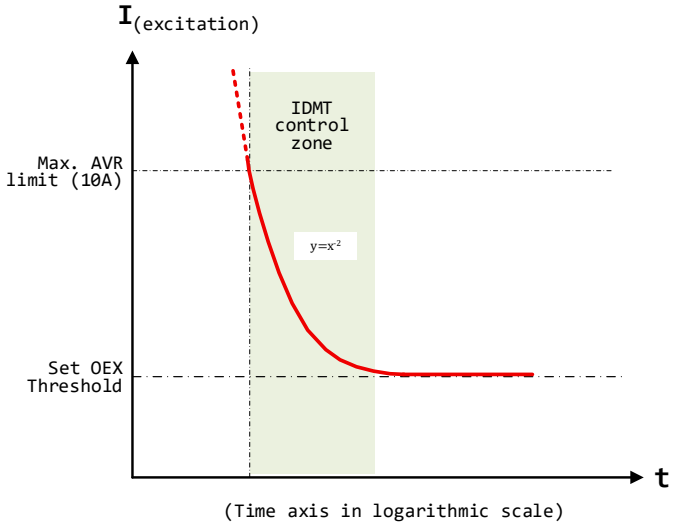
- IDMT curve protection (IDMT), always active and cannot be disabled,
- Limit Activated Time Delay (LATD)

IDMT protection function calculates the "Thermal Load" on the "Excitation Winding" and the "AVR Power switching circuit", based on "IDMT Curve Fitting" technique and cannot be disabled. "Time Integrated" thermal limit control is

dominant and AVR will HALT excitation without any time delay, once this limit is reached. IDMT protection trip function automatically sets internal fault flag and AVR shuts down.

The IDMT control curve is based on **"IEC Standard Inverse Curve-A"** (graphic is shown above) and "OEX Threshold" value sets the nominal current value of the IDMT curve calculation and effects the TRIP characteristics of the protection function. Therefore, parameter **"[P400]"** must be set according to the specifications of the alternator. For other types of curve fitting, please contact the AVR manufacturer.

Proper setting of "OEX Protection" function is crucial for a reliable operation and therefore, user needs to consider the limits of the "Excitor Winding" and the operational environmental conditions. "OEX Threshold" current value setting determines the maximum steady current magnitude of the IDMT function and therefore should be set according to the operating conditions of the alternator. The function is shown on figure below:



LADT protection is a second measure of protection, where the trip delay time can be set according to load characteristics of the alternator. If the operating conditions are adverse (bad ventilated locations, operating at elevated temperatures), user can set a second level of protection, based on the total time that the excitation exceeds "OEX Threshold" level. The "DELAY Time" register is automatically RESET back to ZERO every time the "Excitation Current" falls below the set "OEX threshold limit", therefore protection characteristics is somewhat different than the IDMT model running in the background, which cannot be disabled.

If the TRIP state is reached due to high-current demand for a prolonged period, AVR Excitation cut off will activate and the AVR will shut down.

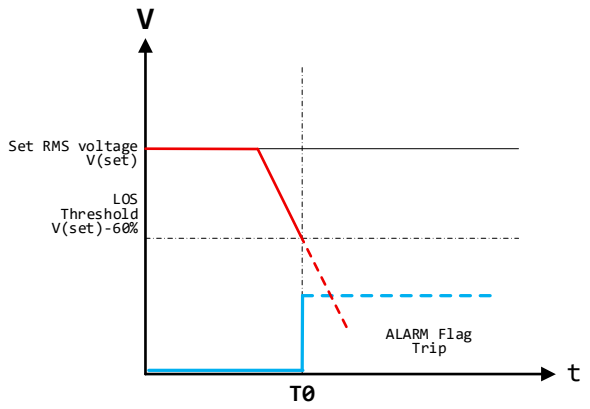
The IDMT protection function calculates the "Thermal Load" on the AVR heatsink and acts on the "OEX Threshold" parameter setting. Therefore, user MUST select correct AVR model with the appropriate EXCITATION DERIVE" capacity, usually above the maximum EXCITATION current required by the alternator and set the "OEX Threshold" parameter accordingly.

	If OEX protection is activated due to adverse operating conditions, the AVR will shut down, and excitation will stop. Since the thermal load on the windings and the AVR drive stage are calculated by the IDMT function, be aware that, AVR cannot track how long the generator cooled before it starts again. If the generator is switched on again before the windings are sufficiently cooled, the actual winding temperature may rise above the limits of the alternator and catastrophic failure can happen. Therefore, after OEX Trip, ensure that the alternator is cooled down to its normal operating temperature levels so that, OEX Protection function will function within its safe limits.

9.2: Loss-Of-Sense (LOS) protection function:

When the AVR is connected to sense voltage, embedded software continuously controls the difference between the sensing voltage and its internal set reference value. If the sensing voltage value drops below a preset calculated value, AVR will consider this as a “Loss-of-Sense” fault and trigger an internal FAULT flag, and this will result in AVR shut-down without any delay.

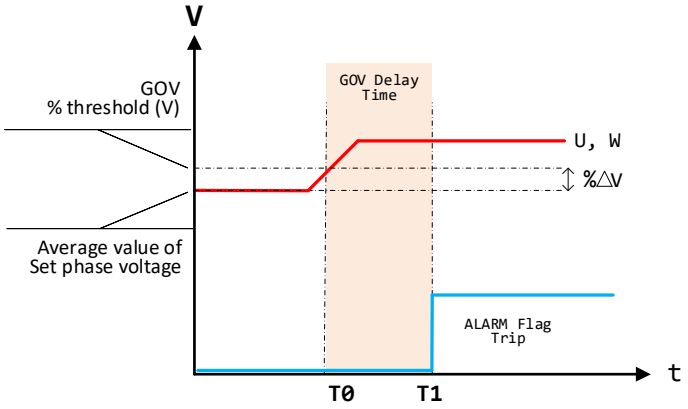
“Loss Of Sense” voltage difference is fixed internally as -50% in comparison to the selected “RMS Phase Voltage” of the alternator. Function monitors the difference of voltage from the set alternator RMS phase voltage parameter and triggers an ALARM flag.

Protection Function		Action	Graphical presentation:
Loss of Sense		no-delay trip	

9.3: Generator Over Voltage (GOV) protection function:

DAVR20 can control the alternator phase voltages to make sure that, generator voltage does not exceed a specific set value margin. This type of failure can be caused due to an internal failure of the AVR or type of load connected to the alternator (capacitive load).

If the function is configured correctly, it can trigger an ALARM condition or TRIP the AVR to stop excitation. The operation of the function is based on the calculation of 3-phase average voltage, compared to the “RMS Alternator Set Voltage” level and if the difference exceeds a certain margin (as configured by the user), alarm will automatically trigger after a delayed period. The configuration of GOV function and its logical operation is explained in the table below:

Parameter Number	Parameter Description	Units	Parameter Limits	Graphical presentation:
[P425]	GOV percentage	%	0 – 50 (Default is 20%)	

[P426]	GOV DELAY time	Sec.	0 – 10 (default = 10 sec.)	DELAY time can be set up to 10 seconds.
[P431]	GOV trip activation	-	[P431] = 0	TRIP function is DISABLED
			[P431] = 1	TRIP function is ENABLED

[P425] is set as a percentage of the set RMS alternator voltage. If for example, the set AVR regulation voltage level is 400Vac, then setting [P425] = 20 means that, AVR will trigger an internal alarm flag if the voltage exceeds 20% of 400Vac, which is 480Vac. Once this set threshold is exceeded, an internal GOV Delay timer will start timing. If the voltage falls below the "GOV Threshold Limit" value before the "GOV Delay Time" period, the flag is automatically RESET, and the timer also resets to zero. If TRIP is enabled, AVR will switch off the excitation drive and stop completely.

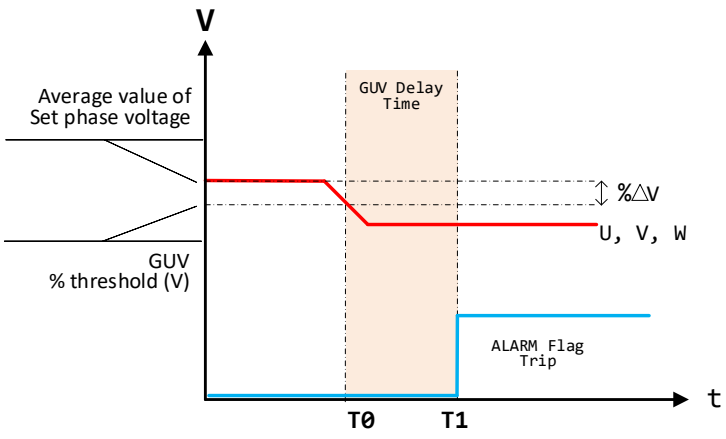
9.4: Generator Under Voltage (GUV) protection function:

DAVR20 monitors the alternator voltage and set an alarm action, if the voltage falls below set RMS alternator reference control level. Like GOV protection function, the AVR will compare the alternator voltage against configured "GUV Percentage" level and initiate an internal "GUV Delay Timer" before triggering any TRIP function.

"GUV Percentage" is set as a percentage of the set AVR reference voltage value. If for example "GUV Threshold Level" is set to 20%, then the Under Voltage Threshold level will be 320Vac and AVR will control the protection function against this value.

Falling below the "GUV Percentage" value, an internal FLAG will be set and after the delay time, a TRIP protection activation will trigger.

Function parameter settings and operation is explained on more detail in the table below:

Parameter Number	Parameter Description	Units	Parameter Limits	Graphical presentation:
[P433]	GUV percentage	%	0 – 50 (Default is 20%)	
[P434]	GUV DELAY time	Sec.	0 – 10 (default = 10 sec.)	DELAY time can be set up to 10 seconds.

[P439]	GUV trip activation	-	[P439] = 0	TRIP function is DISABLED
			[P439] = 1	TRIP function is ENABLED

If the generator voltage rises above during “GUV Threshold” level during “GUV Delay Timer” period, the timer resets its count and will stay in reset condition until the next limit violation.

9.5: External Pot connection error:

If the external pot is connected and generator is running, DAVR20 continuously monitors the external pot connection. If the alternator voltage is trimmed, using the external pot connection, AVR will regulate according to the trimmed voltage level, set by the external pot.

If one or both external pot wires are broken during operation, AVR will carry on regulating the alternator voltage according to the previous voltage setting, set by the external pot, until the generator is intentionally shut down by the user. During the next start-up of the generator, AVR will check the external pot connection and if it is not repaired, AVR will regulate the generator voltage according to the voltage set point of the VLT pot on the AVR unit. Recovering the AVR external pot connection again will allow the AVR to regulate according to external pot setting again.

9.6: Alarm FLAGS and Alarm output RESET:

If an ALARM condition occurs on DAVR20, the alarm flags register will set and latch, and the AVR unit will remember which alarm has triggered the alarm condition. Users can connect via the onboard USB bus and view all the alarm list in the order of occurrence.

The ALARM log in the memory location is arranged as a FIFO type storage, and the depth is up to 64 alarms. As soon as the ALARM log memory is full, the next alarm that occurs will be written over the oldest alarm flag and the log moves down as the new alarms occur. There is also a pointer INDEX which indicates the oldest alarm register position so that the users can follow the list in the correct order.

If the user wants to clear the current alarm trigger state, parameter “P103” can be used to RESET the current alarm condition. If the ALARM condition no longer exists, setting this parameter to “0” will clear the output. If the alarm condition still exists, the flag will set again automatically.

Parameter Number	Parameter Description	Setting limits	Explanations:
[P103]	Clear Output Errors	0	Clear all internal ERROR flags
		1	Internal ERROR flag is activated

9.7: Alarm LED Indication:

DAVR20 is built with an ALARM and STATUS LED indicator on the unit, and it is an RGB LED. Operation status indication is explained below:

STATUS	LED Indication:	Explanations:
AVR operating	GREEN, continuous	AVR is operating under normal conditions, no alarms
AVR Fault Condition	RED, continuous	There is an ALARM condition
USB Communication	BLUE, flashing	USB communication is normal, BLUE LED flashing if port is connected and communicating

If there is an ALARM condition and the AVR is shut down due to the alarm condition, user can connect with PC-Tools SW package to check what alarm caused the system to shut down. User can clear the alarm FLAGS before starting the AVR again, but this is not necessary. During the next start-up sequence, the AVR will give a RED alarm indication and then go back to normal operating condition, if the alarm condition is removed. If the alarm condition is still persistent, AVR will shut down again and register the cause of the failure in its alarm log memory.

9.8: Resetting parameter settings:

If the user wants to set the parameters back to “Factory Default” setting values, it is possible to do so by setting parameter [P203] to “1” and this action will reset all the AVR parameters back to factory default values. Utilisation of this parameter is shown in the table below:

Parameter	Parameter setting range:	Explanations:
[P203]	0	Flag is set to “0” automatically if any of the parameters are changed by the user.
	1	If [P203] is set to “1” via PC Tools S/W, all the parameters are forced to “Factory Default” values.

9.9: Reset internal engine hours meter:

DAVR20 has an integrated clock (not a real time clock) which keeps the time while the AVR has power across its P1 and P2 terminals. Therefore, this internal timing register keeps an approximate value of AVR working hours, which also roughly corresponds to engine working hours value.

If there is an alarm detected by the AVR, the alarm log stores the alarm type, stamped with its internal timer register value. When the alarm/event log is reached by the user via PC Tools S/W, it is possible to see the time of alarm/event condition activated with respect to this internal timing register. If user wants to reset this timing register, parameter [P204] can be used. Operation is explained in the table below:

Parameter	Parameter setting range:	Explanations:
[P204]	0	Normal operating condition
	1	If [P204] is set to “1” via PC Tools S/W, the internal timing register is reset to “0000” and will start timing next time the AVR is energised.

10: DAVR20 Parameter List:

10.1: Internal "Read Only" registers (cannot be set by the user):

No:	Parameter:	Unit:	Min.	Max.	Default	Explanations:	Mask:	Effect:
P002	WU RMS Voltage	V	0	600	0	Phase – Phase RMS Voltage measurement		
P008	WU Frequency	Hz	0	80	0	Phase – Phase Frequency measurement		
P014	Field Current RMS	mA	0	10000	0	Field Current RMS measurement		
P025	AUX Voltage Input Value	V	0	10	0	Auxiliary voltage input measurement		
P027	VOLTS Pot	%	0	100	0	VOLTS Trimmer measurement. Percentage of the effect on the output voltage		
P028	STAB Pot	%	0	100	0	STAB Trimmer measurement. Percentage of the effect on the PID parameters		
P033	EXT Pot	%	0	100	0	External pot measurement		
P034	EXT Pot Connected		0	1	0	External pot connection status flag. Reference voltage would stay same in case of broken pot. It will return to reference voltage on restart if there is no pot connected.	0: N/A 1: Connected	
P035	Controller State		0	6	0	AVR status	0: Pre Init 1: Init 2: Startup 3: Standby 4: Soft Start Delay 5: Soft Start 6: Normal Operation	
P037	Effective Reference Voltage	V	0	580	0	Actual voltage reference that is AVR trying to reach. In relation with Onboard VOLTS pot external pot UFRO LAM DROOP		- P100 - P25 - P26 - P27 - P29 - P33
P041	Calibration Ready		0	1	0	Calibration status parameter. Check 'Calibration Verification' parameter to verify		
P042	Configuration Ready		0	1	0	Configuration status parameter. Check 'Calibration Verification' parameter to verify		
P043	DAVR Ready		0	1	0	AVR is ready to operate no latched errors		
P044	USB		0	1	0	USB Connected		
P046	12V Ready		0	1	0			
P049	UFRO		0	1	0	UFRO function is ongoing. detected Low Frequency		
P052	OUT TRIP		0	1	0	AVR Output Cutoff		
P055	OEX		0	1	0	Over Excitation Protection Activated		

P057	LOS		0	1	0	Loss Of Sense Protection Activated		
P058	GOV		0	1	0	Generator Over Voltage Protection Activated		
P059	GUV		0	1	0	Generator Under Voltage Protection Activated		
P093	Maximum Ambient Temp History	°C	0	85	0	Maximum ambient temperature of this AVR has ever exposed		
P094	Minutes	Min	0	59	0	Generator working time		
P095	Hours	Hr	0	23	0	Generator working time		
P096	Days	D	0	364	0	Generator working time		
P097	Weeks	Wk	0	51	0	Generator working time		
P098	Years	Yr	0	99	0	Generator working time		
P099	Centuries	C	0	99	0	Generator working time		

10.2: Parameter list for user configuration:

No:	Parameter:	Unit:	Min.	Max.	Default	Explanations:	Mask:	Effect:
P100	RMS Voltage Set	V	100	480	100	Nominal RMS Reference Voltage. Effected by UFRO LAM DROOP and Pots.		
P101	AVR Start		0	1	0	AVR's start status flag. Also, can be used to manually start AVR if there is no error.	0: Stop 1: Start	
P102	AVR Auto-start		0	1	0	AVR auto start setting. If enabled AVR will start as soon as there is no errors.	0: Disabled 1: Enabled	
P103	Clear Output Errors		0	1	0	Clear error flags setting. Note: flags will automatically turn on if error continues.	0: Disabled 1: Enabled	
P104	Start Delay	S	0	7200	0	AVR wait time in seconds while generator starting.		
P105	Start Frequency	Hz	25	75	25	AVR ramp up start frequency while generator starting. AVR will wait until sense frequency reaches this level.		
P106	Soft Start Time	S	1	7200	1	AVR ramp up time while generator starting.		
P107	Reference Change Ramp Limit Rate	V/S	1	100	50	Reference Voltage limit for not causing unstable reference while using pots etc.		
P109	Minimum Reference Percentage	%	1	100	75	Sets Minimum Reference setpoint limit percentage according to Reference RMS.		
P110	PID Kp		0	2048	425	Proportional coefficient of the controller. Increasing it will cause faster AVR reaction but worse steady state stability.		
P111	PID Ki		0	2048	250	Integral coefficient of the controller. Increasing it will cause better steady state stability but worse reaction time.		
P112	PID Kd		0	2048	125	Derivative coefficient of the controller. Increasing it will cause faster AVR reaction but worse steady state stability.		
P117	UFRO Knee Point	Hz	40	65	48	This point will determine at what frequency AVR starts derating output voltage. It is used while taking block load.		
P118	DIP Rate	V/Hz	0	80	8	This rate will determine how much drop will be applied to output voltage. It is used while taking block load.		
P119	DWELL Time	V/S	0	480	0	This rate will determine how fast should output voltage recover after derating. Increasing it will cause faster recover time.		
P120	LAM Mode Selection		0	1	1	Selection of the recover after derating mode. Should be changed according to block load performance of the system.	0: NORMAL 1: ENHANCED	

No:	Parameter:	Unit:	Min.	Max.	Default	Explanations:	Mask:	Effect:
P123	AUX Input Mode		0	3	0	Auxiliary input mode selection. AUX input will affect output voltage. In case of external pot connection this input should be disabled.	0: Disabled 1: -5 / +5V 3: 0V – 10V	
P124	AUX Input Range	%	0	100	30	Auxiliary input's effect range on output voltage		
P139	VOLTS Trimmer Effective Range	%	0	30	30	VOLTS trimmer effective range on output voltage.		
P140	STAB Trimmer Effective Range	%	0	30	30	STAB trimmer effective range on controller parameters.		
P142	External Pot Effective Range	%	0	30	30	External pot effective range on output voltage.		
P203	Reset Parameters To Defaults		0	1	0	Reset all parameters to their defaults.	0: - 1: Reset	
P204	Reset Engine Hours		0	1	0		0: - 1: Reset	
P400	OEX Threshold	mA	0	5000	5000	Over Excitation Trigger Threshold		
P402	OEX Delay	S	0	60	10	Over Excitation Delay Time		
P418	LOS Delay	S	0	25	5	Loss Of Sense Delay Time		
P425	GOV Percentage	%	0	50	20	Generator Over Voltage Trigger Level		
P426	GOV Delay	S	0	10	10	Generator Over Voltage Delay Time		
P431	GOV Trip		0	1	1	Generator Over Voltage Output Trip Flag	0: Disabled 1: Enabled	
P433	GUV Percentage	%	0	50	0	Generator Under Voltage Trigger Level		
P434	GUV Delay	S	0	10	10	Generator Under Voltage Delay Time		
P439	GUV Trip		0	1	1	Generator Under Voltage Output Trip Flag	0: Disabled 1: Enabled	
P9975	Device BL version		1000	32767	1000	Current Bootloader version AVR		
P9976	Device S/W version		1000	32767	1000	Current S/W version of AVR		

11- Basic Trouble shooting steps:

If the AVR is connected and the generator does not perform according to specified performance, then there may be problems either with the installation or the AVR settings. In this case, following steps can be applied to fix some of the major possible problems with the system.

11.1: AVR is connected and there is no voltage at the alternator output:

If the AVR is wired into an alternator and during start-up, there is no voltage generation on the alternator stator terminals, please follow the steps below:

1- Check AVR wiring and ensure that, the AVR is installed properly and wired according to the user information given in this user manual. Ensure that, all the wires are properly installed, and all connections are secured and tight,
2- If there is still no voltage generation, check with a multimeter that; the alternator FIELD winding is not open and showing the correct impedance (Ω value) as specified by the alternator manufacturer. Check FIELD wiring polarity and make sure the polarity is correctly wired on the AVR,
3- If there is no voltage generation, check the residue voltage of the stator winding (or AUX winding if connected in AUX configuration) connected to P1 and P2 terminals of the AVR. Disconnect P1 and P2 terminals on the AVR unit, run the generator and ensure that, the residue voltage across the wires to P1 and P2 terminal reads a minimum of 6Vac rms. If this voltage value is not present, then flash the field with an external 9Vdc battery and ensure that, the residue voltage is back and greater than 6Vac rms. Then connect the terminals of P1 and P2 and run the generator.
4- If there is still no voltage generation, check the rotor diodes and ensure that, they are all operating properly,
5- If these is still no voltage generation, it is possible that the AVR may be damaged. Replace the AVR unit with a new one, and repeat the above steps based on the same conditions.

11.2: Voltage is generated but voltage reading is not correct value:

If the voltage generated by the alternator is not reading the correct value under normal running conditions, then follow the steps below to fix it:

1- When the generator is running at normal conditions, if the voltage generated is not matching the correct required voltage value, make sure that; “voltage range” is selected correctly.
2- If still voltage reading is not correct, check the VLT pot and ensure the required voltage value can be set when the VLT pot set around middle position,
3- If still not correct, check that the engine is running at correct speed,
4- If the voltage is still not correct, check the excitor winding and field current (generator at no load condition) and ensure that, field current value is close to the value of calculated field current, when the generator is running in off load condition, check for bad wiring connections,
5- Check rotor diodes and ensure that all diodes are good and working,
6- If the problem persists, replace the AVR unit,

11.3: Voltage stability is not good:

If there is stability problem during operation, follow the steps below:

1- Run the generator in no-load condition and ensure that, the engine is running at correct speed and there is no speed fluctuation while running. If there is speed humming, then check the engine governor settings and ensure that, engine is running at constant speed,
2- Try setting the STB pot carefully, starting from CCW position and slowly turn the pot in CW direction until the voltage swing stops. If the voltage does not become stable through complete span of STB pot, then check the following steps:
    a. Connect with PC Tools S/W and check the PID settings,
    b. Set the STB pot to its mid position,

   c. Follow the instructions given in the user manual to set the PID values to match the alternator's dynamic response characteristics,
   d. Repeat the tests above and set the STB pot to fine tune the AVR

3- Check the excitor winding and check installation and make sure that AVR terminals are wired correctly, and correct voltage selection switch combination is set,
4- Check the rotor diodes and make sure all diodes are operating correctly,
5- Once the stable voltage generation is achieved, then ensure that the generator operates as required under loaded conditions. Also check that, dynamic response during sudden ON load and OFF load conditions are within the required limits,
6- If the problem is not solved, then check the FIELD winding power requirement and check how the power to AVR (wiring of P1 and P2 terminals on AVR unit) are wired? If the field current is too low when the generator is running at no-load conditions, then refer to this manual and check if P1 and P2 is connected across stator phase-phase middle points (SHUNT mode operation only). If yes, then connect P1 and P2 across phase mid-point and NEUTRAL line. Connect P2 to Neutral and P1 to phase middle point. Run the generator at no-load and at full load and ensure that, excitation power is well supplied to the excitor in all conditions.