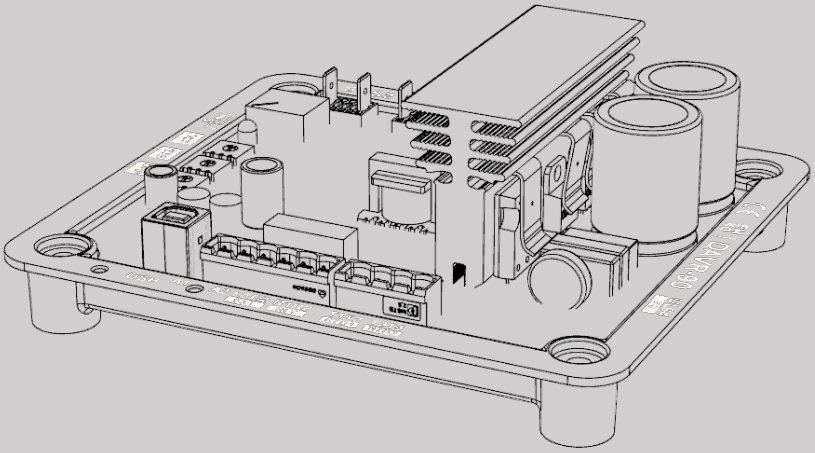
2025



DAVR-90

USER MANUAL

INSTALLATION AND COMMISSIONING

Table of Contents

Revision history:

REVISION	Revision Date	Explanations	PR
R01	11/05/2024		S.K.
R02	16/02/2025	Parameter list update	C.U.
R03	09/06/2025	Graphics update / Parameter list update	S.K.
R04	13/06/2025	Text errors corrected,	S.K.
R05	17/06/2025	IDMT page added, parameter list updated	S.K.
R06	10/10/2025	Specifications list modified	S.K.

DAVR-90

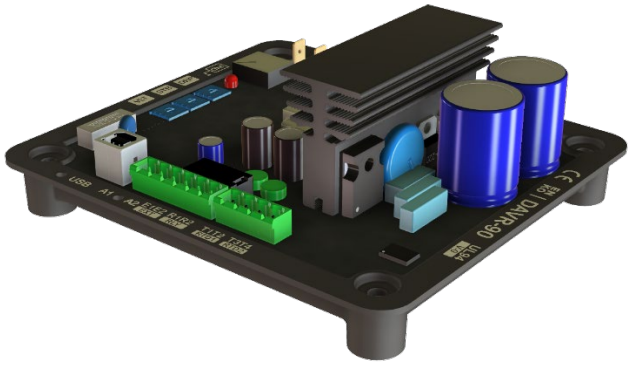
(Digital Automatic Voltage Regulators for Synchronous Alternators)

1- Product Overview:

DAVR90: Advanced Digital Voltage Regulators

The DAVR90 is engineered for superior performance in synchronous alternators with excitor systems. Its design is based on IGBT technology with high-speed switching stage for better dynamic performance in wide range of applications.

An advanced microcontroller within the unit captures all analogue signals from the alternator, converting them into digital form for processing according to the embedded firmware. The control functions operate on specially developed mathematical models tailored for excited synchronous alternators, delivering enhanced performance that surpasses both analogue and digital AVR units available on the market.



Based on its digital control architecture, DAVR90 achieves excellent voltage regulation over a wide range of applications with harmonically distorted loads, which results in exceptional performance.

DAVR90 is equipped with advanced protection functions, which allows safe operation for the alternator and its connected load. All safety limits are configurable such that precise adaptation for all application modes is possible.

The DAVR90 features True Over-Excitation Protection, independent of the alternator field impedance. Its integrated Inverse Definite Minimum Time (IDMT) function continuously monitors the field winding load, preventing heat accumulation and thermal runaway in cases of intermittent high-load applications. This ensures reliable protection against alternator malfunctions.

In parallel connected multiple generator applications, precise and stable control of reactive load sharing makes DAVR90 one of the best choice AVR on the market.

All AVR parameters can be fully configured by the user before operation. On-board USB port enables direct connection to the AVR for viewing and configuring parameters via PC without requiring an external power source. All Auxiliary & Communication ports on DAVR90 are galvanically isolated for safe connection, even while the generator is running.

AUX input/output terminals can be programmed based on application requirements. For details on assigning special functions to these i/o terminals, refer to the AUX Terminal Configuration Settings section of this manual.

Designed and manufactured to the highest standards, DAVR90 ensures safe and reliable operation for all generator applications. All components are sourced from Approved Original Component Manufacturers, guaranteeing traceable quality standards. It's high MTBF life cycle ensures reliable operation even under harsh conditions.

Its robust plastic tray construction allows easy and secure mounting on the alternator. The unit can be installed directly onto a metal panel surface or mounted on anti-vibration (AVM) rubber suspensions for enhanced vibration protection. Additionally, the AVR is encapsulated in UL-approved polyurethane material, ensuring high resistance to harsh environmental conditions and offering a superior RTI level.

Since DAVR90 is a fully programmable unit, users should refer to the PC-Configuration Tool manual to customize AVR parameters according to their specific needs.

1.1 Product marking:

DAVR90 AVR units are potted in plastic protective tray for easy mounting and safe operation. All terminals are placed in groups, based on their functional requirements.

All terminal identifications are marked on the plastic tray side flange for clear and easy reading. Terminal data and their functions are given in this manual, and user is requested to refer to the appropriate section of this manual for more detailed information.

Product model is printed on each AVR unit, including any suffix for specific version of the hardware platform. Users are requested to refer to the table, where detailed suffix data is given for the AVR unit. To get more detailed information on the optional features of DAVR90, visit www.enkoelektronik.com web site or contact your local dealer.

On some models, a QR code is printed on the back side of the AVR plastic tray. Scanning this code will open the latest "User Manual" for the AVR in pdf form. The user manual is written in English, but other languages are available on ENKO web site.

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 boxes 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 sales@enkoelektronik.com for further assistance.

These devices comply to CE regulations for EMC radiation and immunity and UL94 for flammability and safety requirements. In some applications, more demanding EMC protection may be required. In this case, additional filters and shielded packaging may become necessary to use. For such applications, contact ENKO to get further information and available accessories.

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 and live parts are exposed. Special care must be taken when handling the AVR units mounted on the alternator. DO NOT contact any of the terminals on the AVR units when the generator is running. Always switch off the generator before servicing the AVR unit. Only authorized technical personal should commission the AVR units. There are no serviceable parts on the AVR, and no attempt should be made to repair 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- DAVR90 Technical Specifications:

Parameter	Value	Conditions
Operating temperature range:	-35°C to +60°C	At full specified rating
	+60°C < -5%/°C <+70°C	-50% power derating from +60°C to +70°C
Storage temperature range:	-40°C to +85°C	No direct exposure to radiant heat source
Sense voltage:	100Vac – 480Vac (576Vac max. phase-phase)	3-phase sensing, 2-phase sensing, phase-neutral sensing, software configurable,
Voltage sensing type:	TRUE rms reading	High-resolution waveform sampling & sensing
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. input	±15% of set voltage (set by parameter)
	Software configuration	Set regulation voltage reference
Current sensing:	1-phase, X/1A class-1	CT connection on “Generator V phase” only
	1-phase, X/5A class-1	
Current overload:	300% of rated value	Set by configuration software parameters according to application requirements
Current sensing operation mode:	Reactive Droop compensation	
	Line voltage drop compensation	
	Stator current monitoring and limiting	
	Short circuit current sustain compensation	
CT load burden:	1VA	3VA maximum
Power input to AVR:	Shunt connection	300Vac max., 25Hz – 75Hz
	Auxiliary connection	
	PMG power input	300Vac phase-phase, 500Hz max
Excitation current:	5.0Adc max.	continuous
	7.0Adc max.	20 sec. max.
	10.0Adc max.	10 sec. max.
Excitation power limit:	300W max.	Under continuous operating conditions
Field impedance range:	15Ω nominal value	5Ω to 50Ω (excitation power limit is limited to 1375W max. continuous)
Field drive:	IGBT controlled	PWM switching drive stage
Voltage regulation:	≤0.25% of set value	<4% of frequency change
	True RMS reading	Regulation to True RMS value of sensing voltage
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)
	Temperature inputs	Pt100 type RTD sensors
	Digital inputs	Configurable
External pot detection:	Yes	Automatic detection of pot disconnection
Loss-of-sense protection:	Yes	Monitor and shut down after set time delay
OEX protection:	Yes	Software setting according to excitation current limits, IDMT protection function,
UFRO setting:	0-10% of nominal set frequency	Software settable knee-point frequency
Dynamic LAM function:	-V/Hz slope setting	0%Ur/Hz to -15%Ur/Hz User settable parameter according to required performance

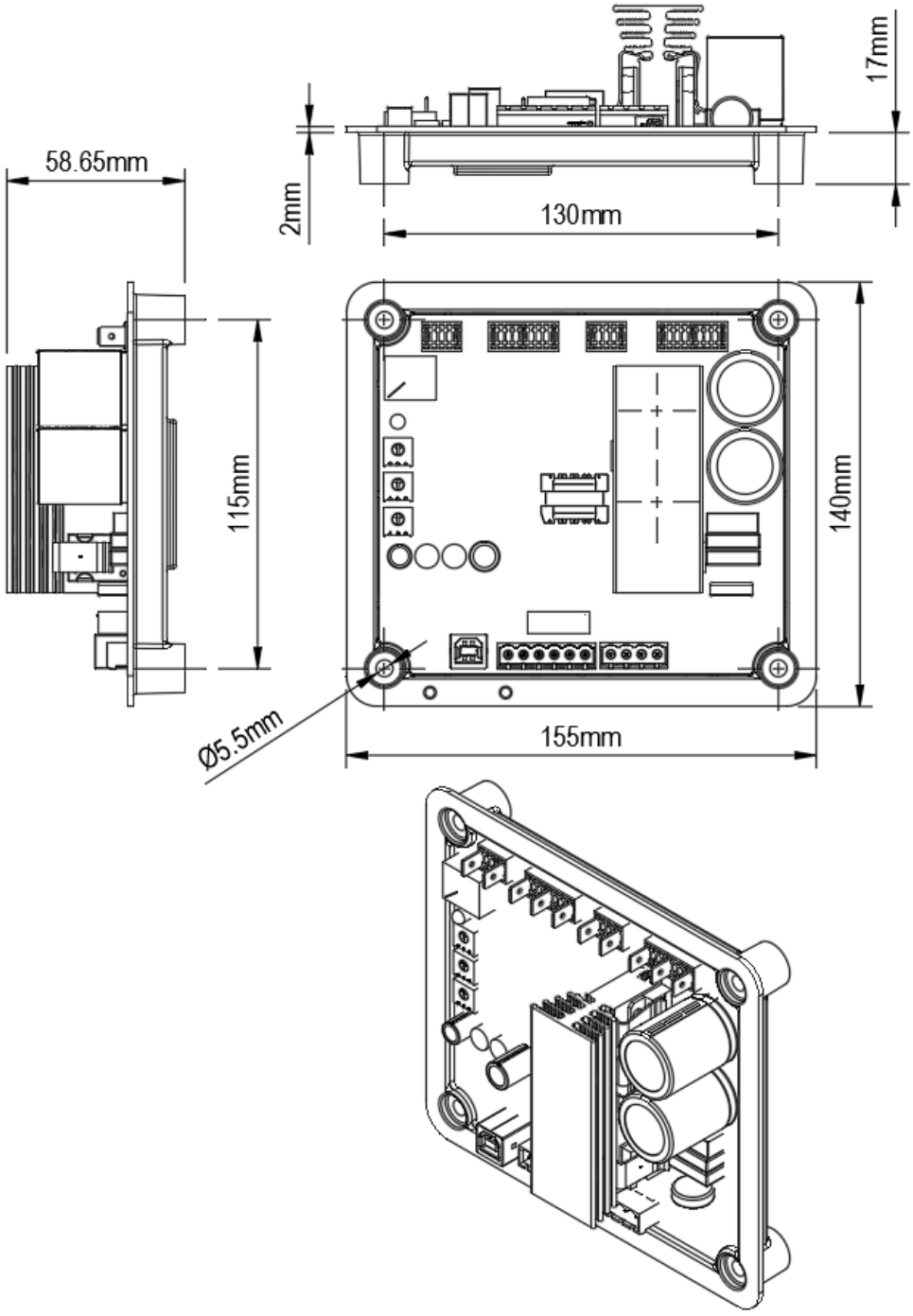
VOLTAGE setting:	±20% of selected range	S/W parameter setting for range, Set with on-board trimming pot
STABILITY setting:	Fine tuning of PID values	
DROOP setting:	-20% to +20% reactive load droop setting	
External pot setting range:	±10% of set voltage value	With 1kΩ external potentiometer, S/W configurable
AUX input trimming:	±10% of input signal	S/W configurable
Communication ports:	USB type-B	For device configuration, galvanically isolated from the power inputs
Indicators:	Single RGB LED	Multifunction indication
Alarm Log:	64 alarm logs register,	FIFO arrangement, viewing with “PCTools” software,
Assembly:	Encapsulated in single plastic tray	Suitable for vertical and horizontal mounting
Weight:	190gr	
Dimensions:	140mm x 155mm x 59mm	Plastic enclosure with printed labels
Conformity to standards:	EN61000-6-2 EN60068-6-4	Immunity EMC Emissions
	EN60068-2-1 EN60068-2-2 EN60068-2-6	Temperature cold test Temperature dry0heat test Vibration
	EN60068-2-27, 30, 78	Environmental tests

2.1 General Features:

- Voltage sensing:
  - Connection with 3-phase, 2-phase or Phase-Neutral configuration,
  - TRUE RMS voltage sensing,
- High accuracy voltage regulation:
  - Better than 0.25% regulation of set value between no-load to full-load change,
  - Capable of tight regulation with high harmonic content load types,
- Wide range of voltage input selection:
  - 100Vac to 480Vac sense input capability, (600Vac max input)
  - Sense voltage range selection by software parameter setting,
- Power input to AVR:
  - SHUNT connection from stator windings,
  - AUX winding from the alternator,
  - PMG connection up to 500Hz
  - External Power supply connection (45Hz to 75Hz)
- High field-current capacity:
  - 5.0Adc continuous excitation current capacity,
  - 7.0Adc for 20 seconds,
  - 10.0A for 10 seconds,
  - 700W excitation power limit (continuous operating conditions)
- Excellent performance with high “block-load” change on the generator output:
  - Built-in LAM function,
  - Adjustable dynamic response
  - Built-in UFRO setting for frequency roll-off point adjustment,
- Load current sensing:
  - Galvanically isolated current sense input,
  - “Reactive droop” control for parallel gen-set operation,
  - “Line drop” compensation for stand-alone operation,
  - “Load Balancing” function,
  - Parameters set via PCTools software,
- Auxiliary inputs:
  - External voltage trimming pot connection input,
  - Analogue voltage control input for external device interface,
  - Configurable as temperature or digital input,
  - USB com port for device configuration
- Adaptive stability control:
  - On-board stability setting pot,
  - Adaptive stability control for different alternator frame sizes,
  - “AUTOTUNE” option with PCTools software
- Built-in device protection:
  - “OEX” (Over Excitation) protection with latch shut-down feature (customised according to alternator FIELD winding impedance, factory setting only, not enabled)
  - “Loss of Voltage Sensing” protection with 3-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:
  - EN61000-6-2
  - EN60068
  - CE safety for emissions and immunity,
  - UL94 non-flammability,
- Mechanical dimensions:
  - Width: 140mm
  - Length: 155mm
  - Height: 59.0mm

2.2 Mechanical Dimensions:

Mechanical dimensions of DAVR90 AVR unit are shown in figure-1 below:



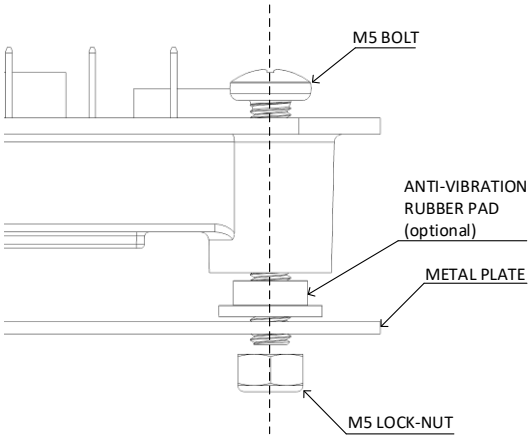
2.3 Mechanical Installation:

Mechanical mounting of DAVR90 is shown in figure 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.

If the AVR is mounted onto a metal plate with rigid mounting technique, ensure that 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. When using “AVM” mounting pads, ensure that the tightening torque DO NOT EXCEED the AVM manufacturer’s compression data.

Ensure that; the plate surface is flat before mounting the AVR unit. Mounting onto a rigid surface with uneven surface geometry will damage the sensitive components inside the AVR unit. Refer to figure below for mounting:



Mounting and Installation Guidelines for the AVR Unit

Different types of **anti-vibration rubber mounts** can be used based on application requirements. Ensure that the **bolt length** is appropriate, considering the combined thickness of the mounting plate and rubber mount (if used). Before operation, confirm that **all four mounting holes** of the AVR unit are securely fixed to the plate.

The **standard mounting position** for the AVR is **vertical**. If necessary, the AVR can also be installed **horizontally**. However, **do not** mount the AVR with the heatsink facing downward, as this will negatively impact its operating temperature range. Additionally, avoid placing the AVR in **air-tight small cavities**, instead, choose a **ventilated location** to circulate the heat generated by the unit effectively.

The **AVR heatsink is "potential-free"** and electrically isolated from the live components of the unit. However, **all AVR terminals are LIVE** and may carry hazardous voltage levels relative to **EARTH**. Exercise caution when handling the unit to prevent electrical hazards.

⚠	Ensure that the AVR is securely mounted according to given specifications. If AVR body is loosely mounted, operation under vibrating conditions may cause mechanical failure of the AVR due to lose fitting.

3- Electrical Installation:

DAVR90 can be installed either in the generator control cabinet or on the alternator. During 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

3.1: Running the AVR for the first time:

When operating the DAVR for the first time, the user must verify all connections and check all the parameter settings. It is essential to ensure that the voltage sense cables are properly connected and that the voltage sense configuration matches the wiring setup. Before powering the DAVR, ensure that voltage across power input terminals do not exceed 300Vac. The user must also verify the isolation status of all inputs, including the USB and communication interfaces, to prevent potential electrical faults.

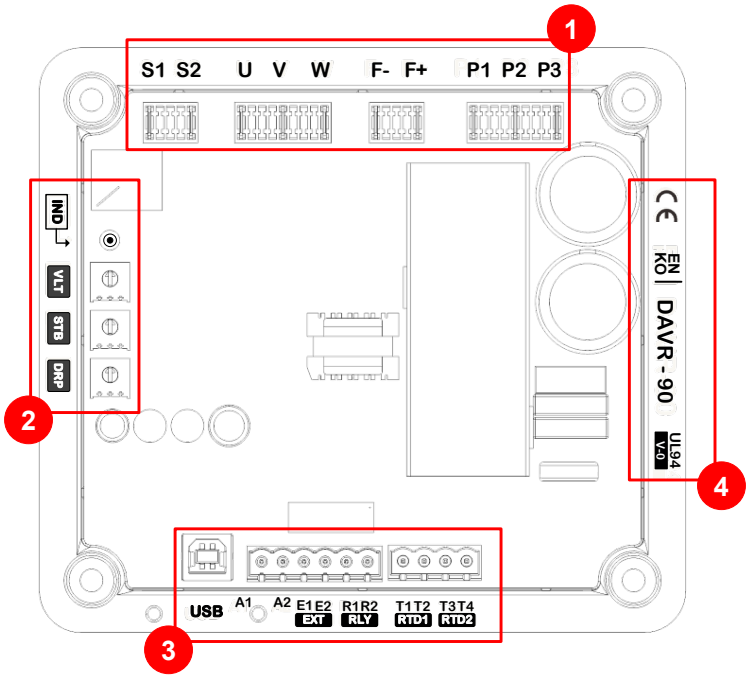
The initial setup requires reviewing of the quick configuration settings to confirm that all essential parameters are correctly set for the generator system and limits comply with your application. As a minimum set up before switching the AVR on, the user must configure the set voltage reference value, sense input type, over-excitation (OEX) limit, PID settings, and Block Load Module (LAM) settings for the DAVR to function correctly in AVR Mode.

Once the generator test is successfully completed, user must proceed with configuring additional parameters, including protection settings, analog and digital input configurations, onboard and external potentiometer ranges, droop mode selection and limits, as well as soft start and ramp settings.

If FCR control function is active on your AVR model (please check AVR model configuration for FCR mode operation availability) ensure to set required FCR parameters and make sure you have chosen the correct operating conditions for safe FCR mode operation.

3.2: Definition of Terminals & Indicators:

DAVR90 is equipped with terminals, trimmers, and indicators to fulfil the interface of the AVR unit with the alternator. The terminals are grouped according to their functions, and these are shown in the figure below:



DAVR90 terminal connections (listed according to groups shown in above diagram):

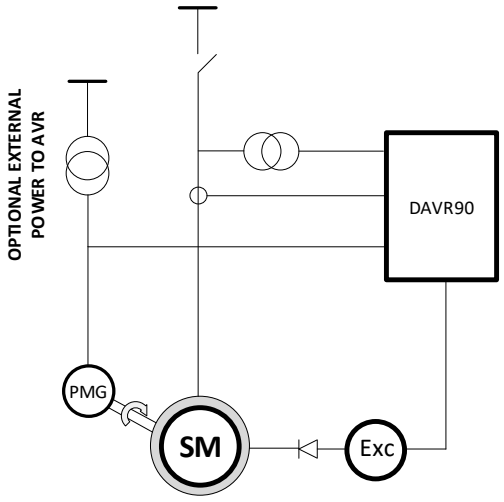
1. Power connection terminals group (fast-on terminal connections for power signals),
2. Trimmers and Indicators group,
3. AUX & Communication terminals (screw type terminals and sockets),
4. Device identification information,

3.2.1: Terminal connection cable sizes:

Terminal cable sizes:			
Terminals:	**AWG**	**Diameter (mm)**	**Area ($mm^{2)}$**
S1, S2, U, V, W	15	1.42	1.5
F-, F+, P1, P2, P3	13	1.82	2.5
T1-T2, T3-T4, A1-A2, E1-E2, R1-R2	17	1.15	1.0
USB	Use USB Type-B cable with moulded terminal only		

3.2.2: General Application diagram:

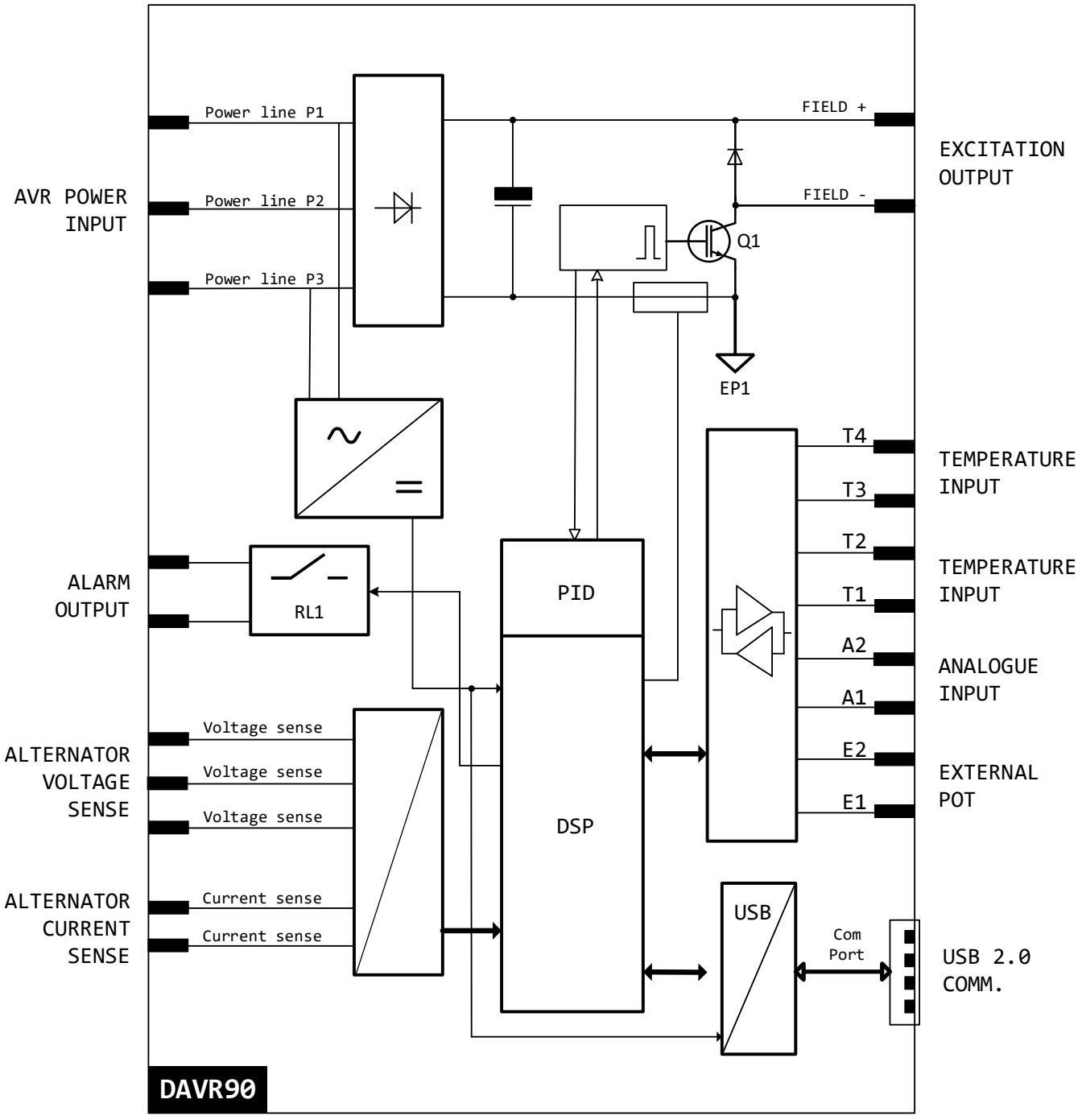
This device is designed to control the excitation field winding of a synchronous machine connected in a closed loop system. Simple application diagram is shown in the figure below:



The power to AVR can be connected in various ways, including an external isolated power supply with correct specifications. The system can also be connected in SHUNT or AUXILIARY power supply modes or can be fed directly from a PMG alternator. If an external AC source is connected, ensure correct voltage and isolation limits for safe operation.

	The unit has an internal capacitor bank and can be charged to high voltages during operation. **DO NOT touch any of the terminals** on the AVR immediately after the generator is shut down. A minimum of 15 minutes is required before attempting to disconnect the AVR from its cable harness, so that all the hazardous voltages are discharged and grounded. **Failing to do so can cause serious damage to the person and/or to the AVR hardware.**

3.3: System Block Diagram:

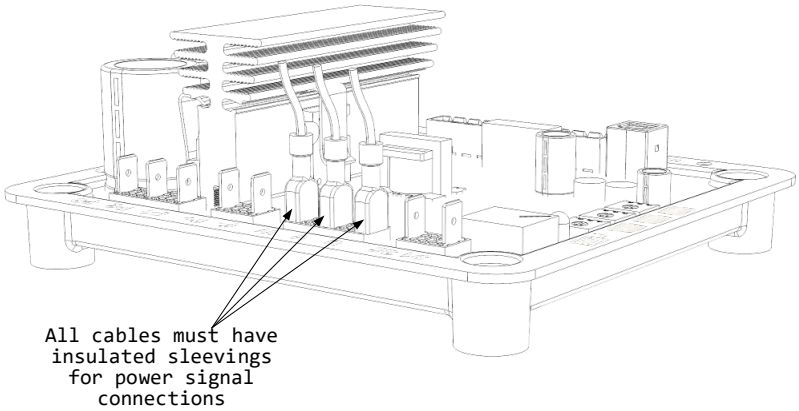


3.4: Power Connection Terminals:

Power signal connections to the AVR are grouped on the top side of the AVR unit and they are arranged as “Fast-on” connection terminals. All the cable ends must be fitted and crimped with appropriate fast-on terminals with proper insulation sleeves.

⚠	All “POWER CONNECTION” cables to the AVR MUST be fitted with proper rubber insulation sleevings. Any connections without proper sleevings will cause AVR unit to fail during operation.

Connection of proper insulating sleevings is shown in figure below:



All power connection terminals MUST be connected, using insulated sleeving cable terminals. AUX terminals and communication sockets are galvanically isolated from the power terminals, but precaution must be taken during application to make sure that insulation levels are not exceeded.

Heatsink is also insulated from the high-voltage potential but care must be taken during application to ensure all safety precautions are taken while operating on the AVR unit.

Heatsink metal surface can reach high temperatures during operation therefore, direct touching of the heatsink metal surface during operation MUST be avoided at all times! After switching off the generator, wait for minimum of 15 minutes before attempting to touch any parts of the AVR unit.

⚠	When installing the AVR unit, ensure that all the wires, to and from the AVR terminals, are neatly bundled together with suitable cable-ties and they DO NOT BLOCK the air flow around the heatsink unit. Make sure that the cable harness is also secured safely such that, terminal connections do not come loose during operation under vibrating conditions.

3.4.1: Alternator Voltage Sensing:

DAVR90 is 3-phase feedback sensing AVR. Voltage sensing can be arranged as 3-phase (connected across U, V and W phases of the alternator) or it can be arranged 2-phase (connected across U and W phase terminals of the AVR). If required, the DAVR90 can also be connected in single-phase “Phase-Neutral” sense configuration as shown in the table below. Terminal arrangements are shown in the terminal Identification table below:

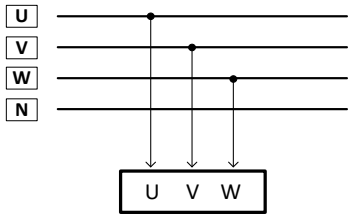
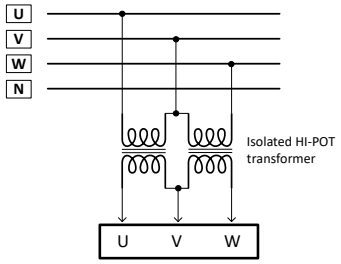
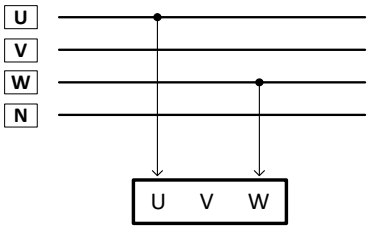
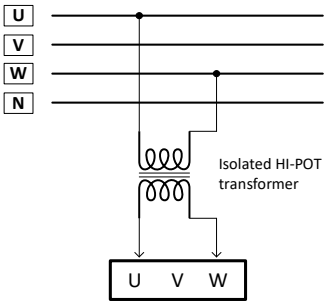
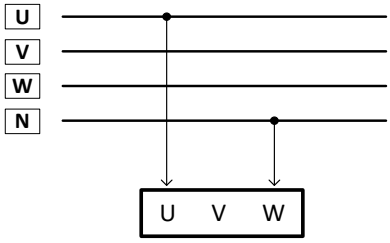
"VOLTAGE Sensing Terminals" identification:			
DAVR90 Terminal ID	Connection	Rating	Terminal group
U	Alternator "U" phase	100Vac to 480Vac (RMS) nominal	POWER CONNECTION TERMINALS GROUP
V	Alternator "V" phase		
W	Alternator "W" phase		

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% continuous. Therefore, when connecting the AVR unit, ensure that correct voltage sensing range is selected from the configuration S/W and the alternator stator windings are configured correctly.

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.

DAVR90 can only regulate the voltage at the point of its sensing terminal connections. Therefore, in the following paragraphs, voltage range selection and voltage adjust pot act with respect to the voltages across the AVR sensing terminal connections. User must select the correct voltage sensing range and set the pot position according to their application requirement.

Possible voltage sensing connections for DAVR90 are shown in the tables below:

Voltage sense connections	Direct connection *(Either from stator main terminals or from winding mid-point connections)*	Hi-pot transformer connection
3-Phase Connection		
2-Phase Connection		
Phase – Neutral connection		Not applicable

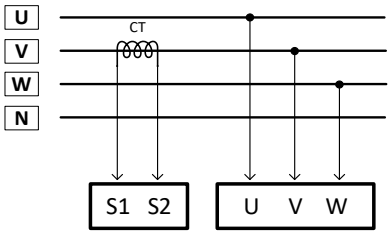
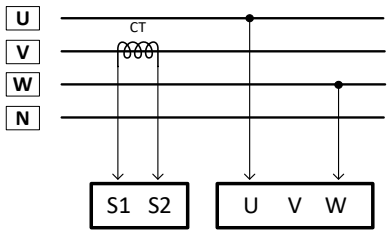
	Voltage Sense connections must match the AVR unit's voltage range. Refer to the manual's voltage range selection before connecting to the alternator. If using SHUNT mode, ensure the AVR's POWER SUPPLY input does not exceed the 300Vac maximum limit. For Current Transformer (CT) connections, follow the manual's guidelines. Incorrect CT connection will impair reactive droop performance and reactive load sharing.

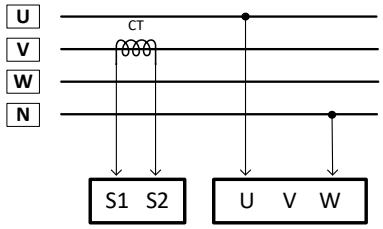
3.4.2: Current Sense (CT) connection:

Refer to the CT connection table below for various CT connection configurations for DAVR90. Current transformer terminals are labelled as S1 and S2 as shown in below illustration:

"CURRENT Sensing Terminals" identification:			
DAVR90 Terminal ID	Connection	Rating	Terminal group
S1	Alternator "V" phase	X/1 or X/5	POWER CONNECTION TERMINALS GROUP
S2			

The CT inputs; S1 and S2 are galvanically isolated and rated to 5A maximum. Current sensing input can be configured as x/1 or x/5 ratio with 0.5% accuracy class. Therefore, current sensing must be configured according to alternator current transformer rating. The CT inputs of AVR is designed to withstand high current peaks, occurring during operation. It is recommended to connect current sensing CT loop only to AVR current sensing terminals (not sharing with other instruments on the generator) if droop compensation is going to be performed. Always connect CT on the alternator to the "V" phase of the alternator stator.

CT connection with 3-phase voltage sensing (CT connected to "V" phase)	
CT connection with 2-phase voltage sensing (CT connected to "V" phase)	

CT connection with phase-neutral voltage sensing (CT connected to “V” phase, Reactive Droop is not possible in phase-neutral connection configuration mode)	

NOTE:

CT connection on DAVR90 is sensitive to phase of the alternator and rotating vector direction. Therefore, user must take special care to which phase the CT is connected. On DAVR90 AVR unit, CT is always connected to the middle phase winding (phase “V”) and the polarity must match the direction of phasor rotation. If droop function operates in reverse characteristic, then change the polarity of CT connection at AVR terminals S1 and S2.

Refer to the CT connection chapter of this user manual, before attempting to connect the power terminals of the AVR units.

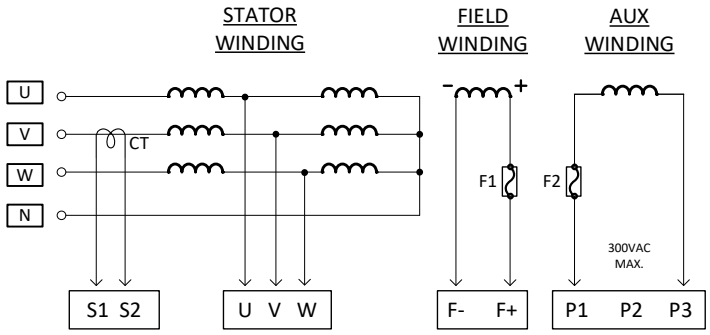
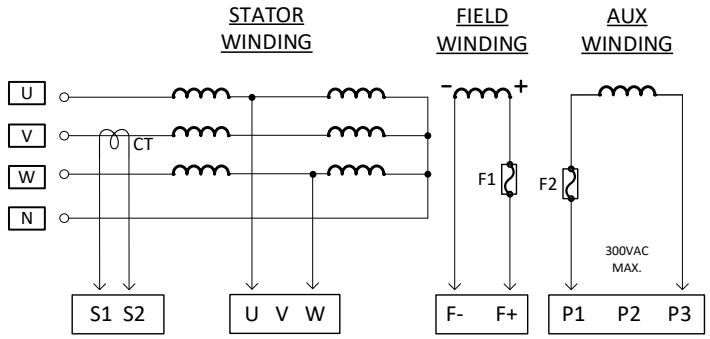
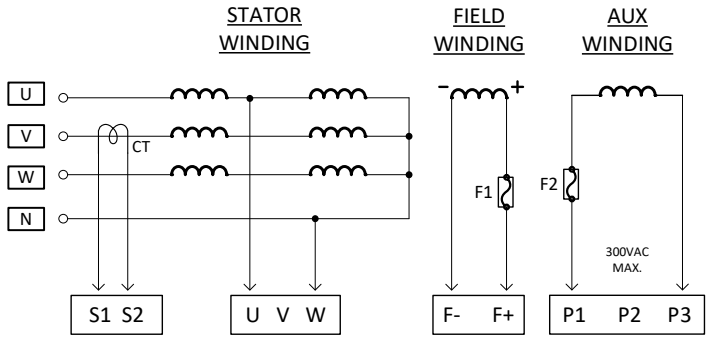
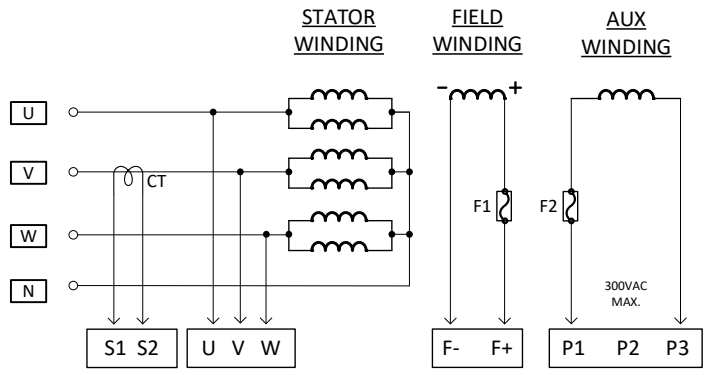
3.4.3: Power Supply and FIELD winding connections:

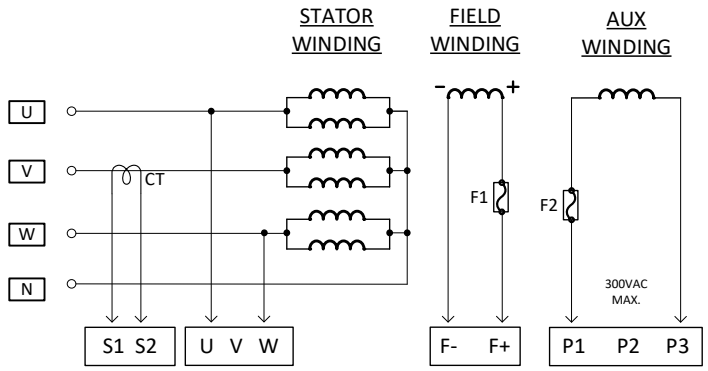
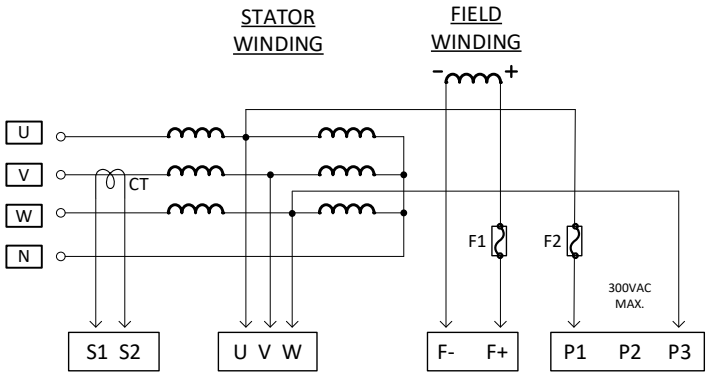
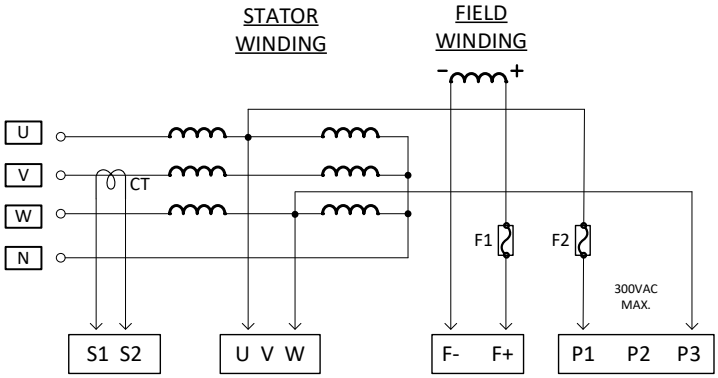
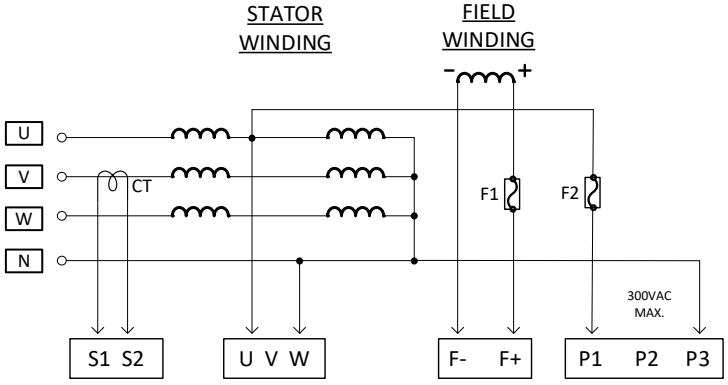
Power Supply inputs (P1, P2 and P3) on DAVR90 is limited to 300VAC maximum. In any application, exceeding this voltage level may damage the AVR unit. Take special care when connecting the voltage sensing input and AVR power supply input in SHUNT connection mode.

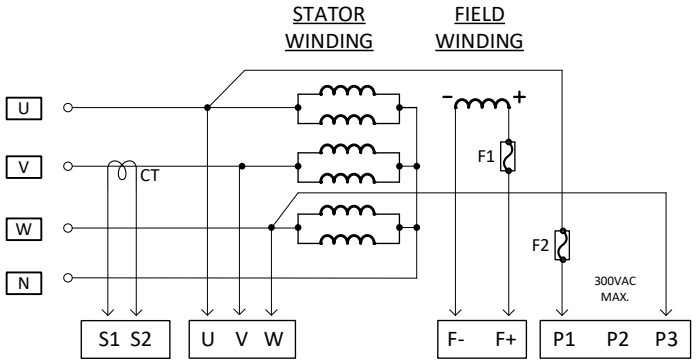
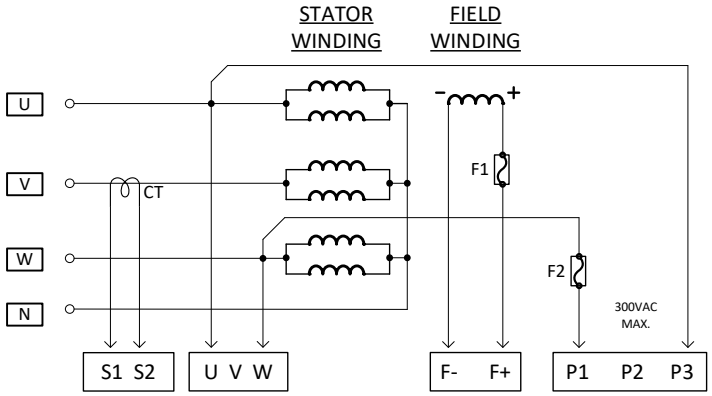
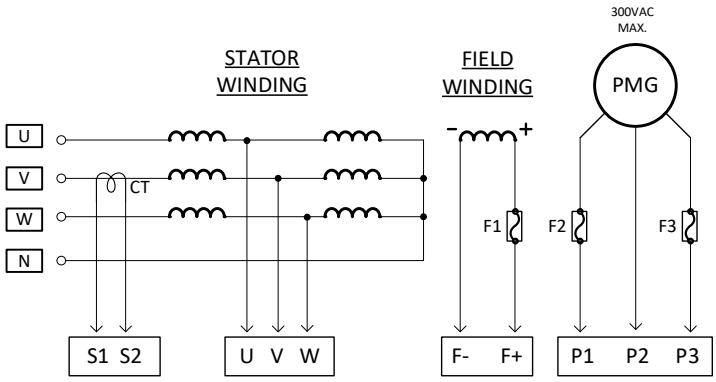
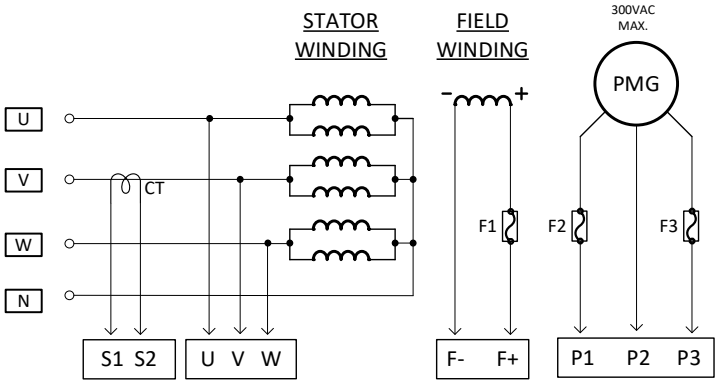
Power to AVR can be connected in “SHUNT” mode or “AUXILIARY” supply mode as required. Possible connection configurations are given in the table below for different arrangement of the alternator stator winding arrangements.

“EXCITATION and AVR POWER INPUT” Terminals identification:			
DAVR90 Terminal ID	**Connection**	**Rating**	**Terminal group**
F-	Excitor winding –‘ve terminal	5Adc (continuous) 7Adc (20 seconds) 10Adc (10 seconds)	POWER CONNECTION TERMINALS GROUP (Terminal group 1)
F+	Excitor winding +’ve terminal		
P1 – P3	AVR Power input connection (Shunt, AUX)	300Vacmax (ph-ph) 25Hz to 75Hz 300W max. continuous	
P1 - P2 - P3	AVR Power input connection (PMG or External 3-phase power source)	300Vacmax (ph-ph) 25Hz to 500Hz max 300W max. continuous	

Possible AVR power connection configurations are shown in table below. 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 “3-phase” voltage sensing, *(Y-Star series connection, 12 leads)*	
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)* *(Reactive Droop not possible)*	
Connection with **AUXILIARY** winding and “3-phase” voltage sensing. *(YY-Star parallel connection, 12 leads)*	

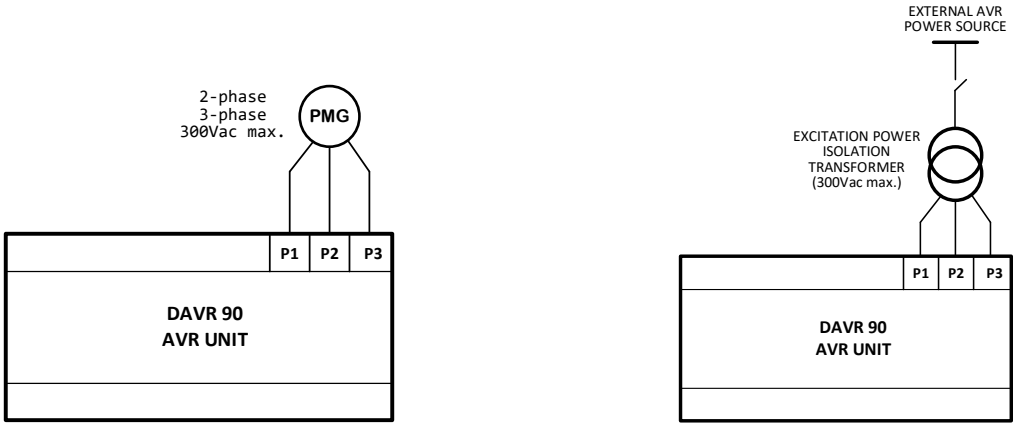
Connection with **AUXILIARY** winding and “2-phase” voltage sensing. *(YY-Star parallel connection, 12 leads)*	
Configuration	**WIRING SCHEMATIC IN SHUNT CONFIGURATION**
Connection with **SHUNT** mode and “3-phase” voltage sensing, *(Y-Star series connection, 12 leads)*	
Connection with **SHUNT** mode and “2-phase” voltage sensing, *(Y-Star series connection, 12 leads)*	
Connection with **SHUNT** mode and “phase-neutral” voltage sensing, *(Y-Star series connection, 12 leads)* *(Reactive Droop not possible)*	

Connection with **SHUNT** winding and “3-phase” voltage sensing. *(YY-Star parallel connection, 12 leads)*	
Connection with **SHUNT** mode and “2-phase” voltage sensing, *(YY-Star parallel connection, 12 leads)*	
Configuration	**WIRING SCHEMATIC WITH PMG**
Connection with **PMG** source and “3-phase” voltage sensing, *(Y-Star series connection, 12 leads)*	
Connection with **PMG** source and “3-phase” voltage sensing, *(YY-Star parallel connection, 12 leads)*	

	Maximum voltage across power supply terminals of DAVR90 is limited to 300Vac max. Do not exceed this limit in all applications, considering the over-shoot percentage of the AUXILIARY and SHUNT windings, when the stator load is removed suddenly. Ensure this limit is not exceeded under all operating conditions.

The DAVR90 power inputs are designed as “**high impedance floating**” connections relative to the sense inputs. They can be connected across either “phase-phase” or “phase-neutral” terminals of the alternator in SHUNT mode. Always connect P1 to the “U-phase” of the alternator in SHUNT mode, while P3 can be connected to either the “W-phase” or the “Neutral” terminal in two-phase configuration.

If an external power connection is required, use an insulating transformer or an isolated AC power source, ensuring it does not exceed the voltage ratings of P1, P2, and P3. The transformer must deliver the required peak power specified and have low impedance to maintain a stable AVR power input under loaded conditions.



All “Power and Sense” input terminals are galvanically isolated from the “Auxiliary & Communication” signal terminals, and the isolation is rated at 500Vac.

3.4.4: Connection with high-voltage transformer:

For applications involving high-voltage stator winding, it is necessary to use an isolation step-down voltage transformer between the stator windings and the sense voltage terminals U, V and W of the AVR unit. In such cases, the sensing voltage selection of the AVR unit must match the transformer secondary voltage.

Since the DAVR90 can be connected in either 3-phase or 2-phase sensing configuration, the "hi-pot" isolation transformer should be connected according to the selected voltage sensing configuration. Configuration software should be used to select the appropriate voltage rating for regulation across the transformer secondary terminals, which should be directly connected to the U-W sensing terminals of the AVR unit. It is important to note that the AVR will regulate the voltage across its sense input terminals, so the sensing voltage parameter should be set accordingly.

In SHUNT mode connection with an isolation transformer, if the same transformer is used for both sensing and power supply, the limited impedance of the transformer may degrade the voltage sensing signals when the maximum excitation load is reached. Unless the transformer power rating is calculated for ohmic voltage drop, it is advisable to use separate transformers for sensing and power supply inputs to the AVR or to use an external AC power source to power the AVR unit.

	When connecting high-voltage transformers for AVR sensing, ensure that, correct phase selection is made with respect to the current measurement transformer (CT) of the alternator, else reactive load sharing may perform badly. Refer to the related information given in this user manual.

In any case, do not exceed the limits of the power supply input terminals P1, P2 and P3 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.

3.5: "Auxiliary & Communication Terminals" connections:

AUXILIARY signal connections and COMMUNICATION port connections are shown in terminal group 3 and 4 in the above illustration. 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.

All AUXILIARY signal terminals are galvanically isolated from the AVR POWER terminals. When connecting signals to the AUX terminals, please ensure that the potential difference does not exceed the AVR isolation limits.

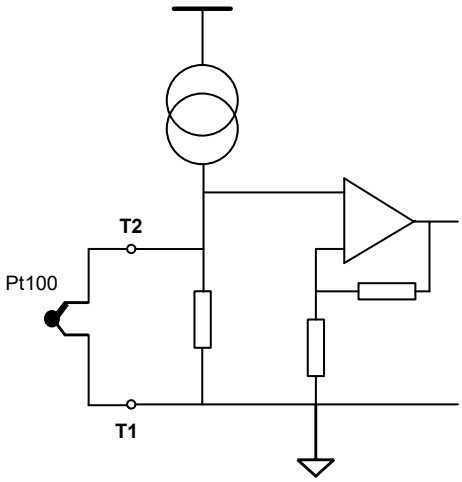
3.5.1: Temperature Sensor connections:

DAVR90 unit is fitted with 2 temperature sensor inputs such that, various temperatures on the alternator can be measured and set to protect the alternator from "overload" or "overheat" conditions. Type of sensors and their respective settings can be examined in more detail under the related topic of this manual.

The sensor inputs are defined in the table below:

"TEMPERATURE SENSOR" input terminals identification:			
DAVR90 Terminal ID	**Signal Description**	**Cable size**	**Terminal Group**
T1 **T2**	• Temperature Sensor input (Pt100, 2-wire) • Digital input-1	Screw type terminal with AWG17 or AWG18 cable size	"AUXILIARY" connection terminals (terminal group-4)
T3 **T4**	• Temperature Sensor input (Pt100, 2-wire) • Digital input-2		

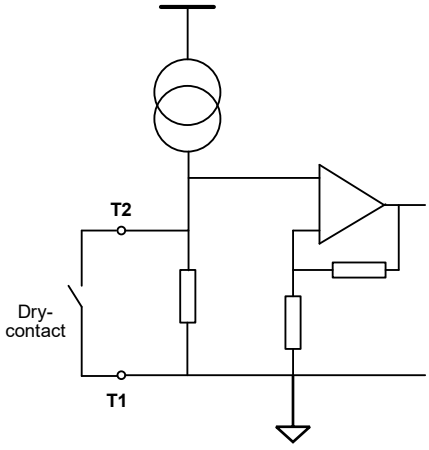
	All AUXILIARY signal inputs share a common power supply and therefore, there is no galvanic isolation between the AUXILIARY signal terminals and the Communication port. When connecting the temperature sensors to alternator windings, care must be taken to ensure safe insulation between the sensor body and the point where the sensor is mounted.



All temperature measurement inputs have the block schematic as shown in the figure above. The “equipotential” ground connection is common to all AUX signal input hardware and therefore, when connecting temperature sensors and external control equipment, care must be taken to ensure safe operation.

3.5.2: Digital Signal connections:

Each temperature sensor input can also be configured as “Digital Input” and configuration can be set via PC-Tools S/W menu. Please refer to the related section of this manual for more detailed setting instructions. Digital input MUST be arranged as “potential-free” contact input which can be connected directly to the temperature sensor inputs as shown in figure below:

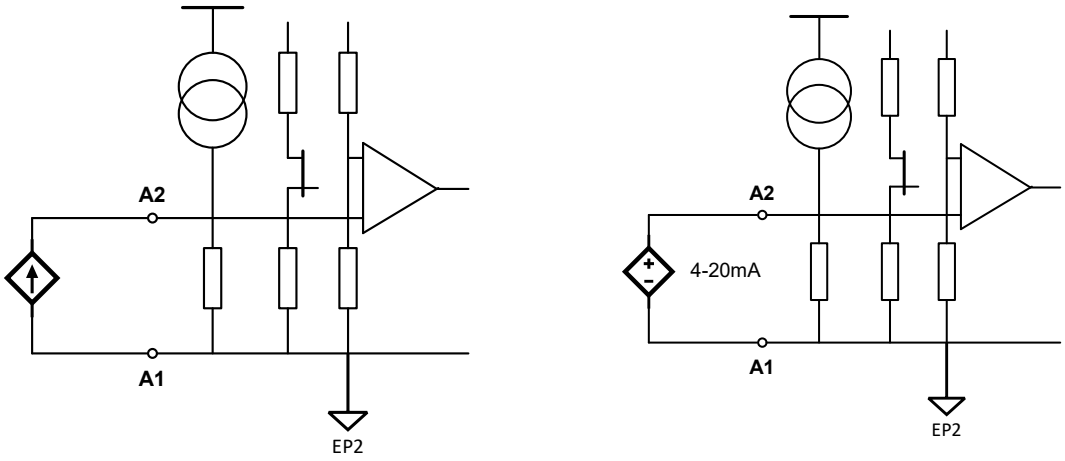


[T1-T2] and [T3-T4] can be set as mixed signal inputs, any number can be set as temperature inputs while remaining of the three inputs can be set as digital inputs at the same time.

3.6: Analogue Signal inputs:

DAVR90 AVR unit has a set of analogue inputs to connect with the external control equipment. This input can be configured to control the AVR voltage regulation reference value, hence controlling the alternator voltage from an external controller. If FCR function is also available (based on the AVR model), this analogue input can be used to set the field current as required by an external control unit.

Reference analogue input block diagram is shown below:



Analogue input signal connection can be arranged as:

- ±5Vdc analogue voltage input
- 4-20mA analogue current input
- 0-10Vdc analogue voltage input

All signal connections are referenced to A1 terminal, which is hardwired to the reference ground potential of the AVR AUXILIARY power supply.

Terminal identification and ratings are shown in the table below:

“ANALOGUE” signal input terminals identification:			
DAVR90 Terminal ID	**Signal description**	**Rating**	**Terminal group**
A1 **A2**	±5Vdc 4-20mA 0-10Vdc	Screw type terminal with AWG17 or AWG18 cable size	“AUXILIARY” connection terminals (terminal group-4)

	All “AUXILIARY & Communications Signal Terminals” group are galvanically connected. Therefore, when connecting analogue signals to the AVR unit, user MUST take appropriate precautions to ensure that device isolation limits are not exceeded.

3.7: External Pot connection:

DAVR90 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:			
DAVR90 Terminal ID	**Connection**	**Rating**	**Terminal group**
E1 **E2**	Screw type terminal with AWG17 or AWG18 cable size	1KΩ/1W Potentiometer (two-wire configuration)	“AUXILIARY & COMMUNICATIONS” connection terminals group

	EXTERNAL POT connections are galvanically connected to the remaining AUX terminals. Therefore, when using external pot function, user needs to ensure that, pot connection cables are not in contact with high-potential voltage sources.

3.8: RELAY contact terminals:

DAVR90 is fitted with an ALARM relay for interfacing with external protection accessories. The RELAY can be configured according to application requirements, using PC-Tools SW menu. Relay action can be linked to any of the failure modes, which the AVR can detect.

“EXTERNAL POT” terminals identification:			
DAVR90 Terminal ID	**Connection**	**Rating**	**Terminal group**
R1 **R2**	Screw type terminal with AWG17 or AWG18 cable size	SPST, N/O contacts 1A/30Vdc contact rating	“AUXILIARY” connection terminals group

Relay output terminals are arranged as N/O contacts and can be configured by the configuration software. Relay contacts are dry-contact type and not connected to any potential internally. Isolation voltage rating of the relay must be observed carefully, if the contacts are going to be connected to different power sources

3.9: Communication Port Connection:

DAVR90 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 galvanically isolated, it is possible to monitor AVR performance while the AVR is live on the alternator. Remember that the isolation barrier is 500Vac and should not be exceed.

USB port also provides adequate power to the AVR, and no additional external power connection is required for configuration.

Terminal identifications are shown in the table below:

"USB" Communication port identification:			
DAVR90 Terminal ID	**Connection**	**Rating**	**Terminal group**
USB	Type-B USB cable connection	Galvanically isolated to 500Vac with respect to power & sense input terminals	"COMMUNICATIONS" connection terminals group

There is galvanic isolation between "POWER CONNECTION TERMINALS" group and "AUX & COMMUNICATION" terminals group. Since "AUX & COMMUNICATION" group terminals are all connected on the same galvanic system, take notice of this when connecting the analogue terminals to an external system, while using the USB com port on your PC.

3.10: Trimmers and Indicators:

DAVR90 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:			
DAVR90 Trimmers ID	**Connection**	**Rating**	**Terminal group**
VLT	VOLTS trimmer	±20% of set parameter value	"TRIMMERS & INDICATORS" group
STB	STABILITY trimmer	K_P setting of PID parameters	
DRP	DROOP trimmer	±10% of set value	

There is also a STATUS indicator LED integrated with the AVR unit. This indicator signals the current 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:

DAVR90 regulates the voltage seen across its "VOLTAGE SENSING" terminals, U, V and W phase connections of the alternator STATOR windings. Since the AVR is designed to regulate the voltage across its sensing terminals U, V and W, user MUST select 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 several different methods to set the regulation voltage reference on the AVR unit:

1. Using "PC-Tool" Configuration Software,
2. VLT trimmer pot position on the AVR unit, (configured with "PC-Tool" S/W),
3. EXTERNAL POT connection on the AUX terminals,
4. ANALOGUE signal input connection at the AUX terminals,

4.1: AVR Voltage Sensing configuration:

As described in the "AVR Wiring Schematic Configuration" tables above, voltage sensing of the AVR can be arranged either as "*Y-Star Series Connection*" or "*YY-Star Parallel Connection*" and based on the wiring configuration, user must select the "Voltage Sense Rating" of the wiring configuration for the AVR unit.

"Sensing Mode Configuration" is set by parameter [P122] according to the table below:

Parameter number:	Parameter Description:	Units/Type	Parameter Settings	Explanations:
[P122]	Alternator Stator Phase wiring configuration selection	Configuration	1, 2, 4	UV, VW, WU configuration (2-phase or Phase-Neutral connection, default = 4)
			7	U – V – W configuration (3-phase connection)

[P122] = 4 (default factory set value) and the AVR is set as "Phase-Phase" sensing configuration, If phase-neutral connected, then the neutral line should be connected to the "W" terminal of the AVR, as shown in the wiring configuration tables above. In all configuration settings, CT must be connected to "V" phase of the stator in the correct polarity.

4-2. AVR "Voltage Range Selection" 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	Parameter Set Limits	Explanations:
[P100]	"Nominal RMS Voltage Set" value. (U-V-W phase-phase voltage value)	VOLT (rms)	100 – 480 (default=100)	Voltage Range Selection: 100Vac RMS to 480Vac RMS (factory default value: 100)
[P139]	"Volts Trimmer Effective range" value. (VLT Pot adjustment range)	%	0 – 30 (default=30)	Adjustment range: ±0% to ±15% of P100 parameter set value, (factory default value: 30)

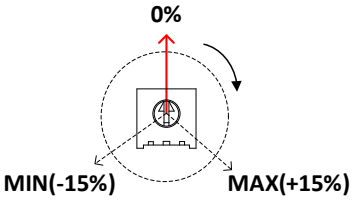
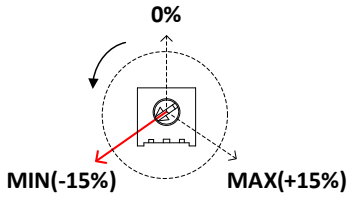
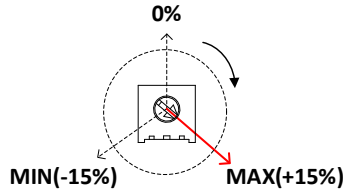
Parameter [P100] sets the voltage regulation reference point with VLT trimmer set to its MID position.

EXAMPLE:

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

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

The result is shown in table below:

Parameter setting:	Alternator stator voltage (U-W):	VLT pot setting:	Explanations:
[P100] = 380 [P139] = 30 (nominal stator voltage is set to 380Vac and pot range to ±15% of 380Vac)	380Vac rms		VLT POT set to mid position (nominal set position)
	323Vac rms		VLT pot set to MIN. position (-15%, turned fully CCW)
	437Vac rms		VLT pot set to MAX. position (+15%, turned fully CW)

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 (nominal voltage set value position), AVR will regulate the alternator voltage at 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 [P139]). 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 requirement.

4.3: Setting the CT ratio on AVR unit:

If stator current is going to be monitored for line compensation or reactive droop compensation, CT must be wired across S1 and S2 terminals of the AVR unit. The CT ratio can either be set as X/1 or X/5 on the AVR unit. Therefore, based on the current transformer used on the alternator, user must set the transfer ratio of the CT on the AVR to ensure that, 1PU of stator current corresponds to the correct value through S1 – S2 terminals of the AVR unit.

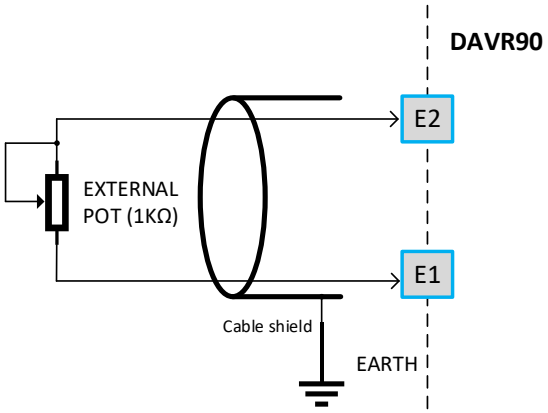
This is done by setting parameter [P135] in the parameter list as shown in the table below:

Parameter number:	Parameter Description:	Units	Parameter Settings	Explanations:
[P135]	Current Transformer transfer ratio	PU of alternator current rating	205	X/5 ratio (1PU = 5A)
			1024	X/1 ratio (1PU = 1A)

4-4. External Pot connection (E1 & E2 terminals):

DAVR90 allows controlling of the alternator voltage via an EXTERNAL POT, connected away from the AVR unit. Connection is shown in figure below:

This pot can be mounted at a remote location on the generator to allow the user to “fine-tune” alternator voltage as required. Maximum cable length should not exceed 3m and must be shielded for safe operation if the cable length exceeds 1m. Up to 1m cable length, twisted cable pair can be used.



If the cable length exceeds 1m, 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. DAVR90 detects the external POT connection status and user is required to set the “External Pot Effective Range” parameter [P142] to suit their application, as shown in table below:

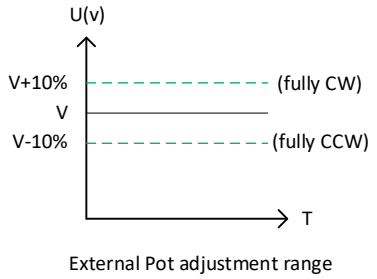
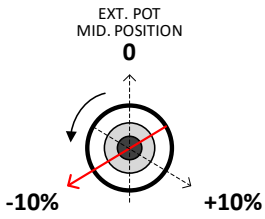
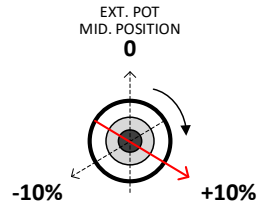
Parameter number:	Parameter Description:	Units	Explanations:
[P142]	External Pot Effective Range	%	Adjustment range: 0% to 30% of set nominal voltage value (factory default value: 30)
[P123]	AUX. Input Mode Selection	0 - 3	Set [P123] to “0” to ENABLE EXT. POT function. (setting “0” for this parameter automatically disables A1-A2 input)

External pot acts on the voltage set value by VLT pot and the device configuration parameters. In the example given below, the VLT pot is set to 380Vac rms (VLT trimmer pot set to MID position) and the “External Pot” effective control range is set to ±10% which corresponds to 380Vac ±40Vac effective external pot set range.

EXAMPLE:

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

Parameter setting:	Alternator stator voltage (U-W):	VLT pot setting:	Explanations:
[P100] = 380 [P123] = 0 [P139] = 15 [P142] = 20	380Vac rms		VLT POT set to 380Vac rms (trimmer at MID position)

(nominal stator voltage is set to 380Vac and pot range to ±10% of 380Vac)  External Pot adjustment range	342Vac rms	 	EXTERNAL Pot set to minimum (fully CCW)
	418Vac rms	 	EXTERNAL Pot set to maximum (fully CW)

4-5. AUXILIARY Analogue Signal connections:

DAVR90 is also equipped with an analogue AUX signal input terminal where an external device can control the alternator voltage via 4-20mA, 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 "0" 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:

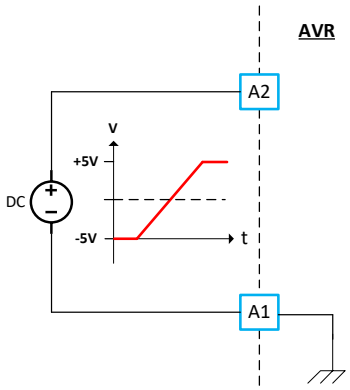
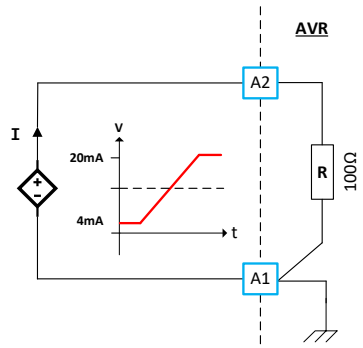
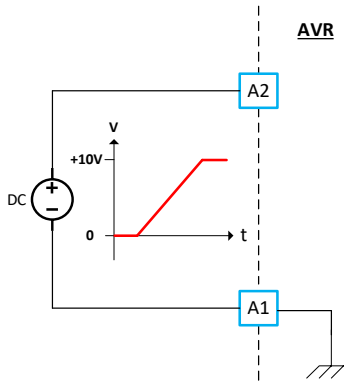
Parameter number:	Parameter Description:	Parameter Set limits	Explanations:	
[P123]	"AUX Input Mode" (Terminals: A1, A2)	0	"AUX Input Mode" function DISABLED	"EXT POT" function is **ENABLED**
		1	-5Vdc to +5Vdc analogue voltage signal input	"EXT POT" function is **DISABLED**
		2	4mA to 20mA analogue current signal input	
		3	0Vdc to +10Vdc analogue voltage signal input	

	If [P123] = 0 then "AUX Input Mode" function is automatically DISABLED and EXTERNAL POT input function is automatically ENABLED. Setting [P123] = 1, 2 or 3" values, EXTERNAL POT control function will automatically be DISABLED and at the same time, analogue signal control will be ENABLED.

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

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.

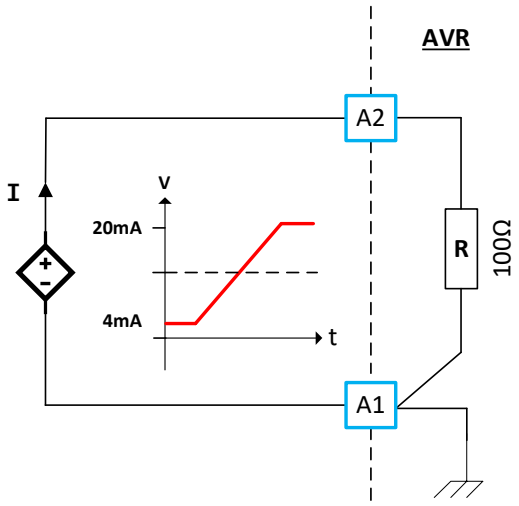
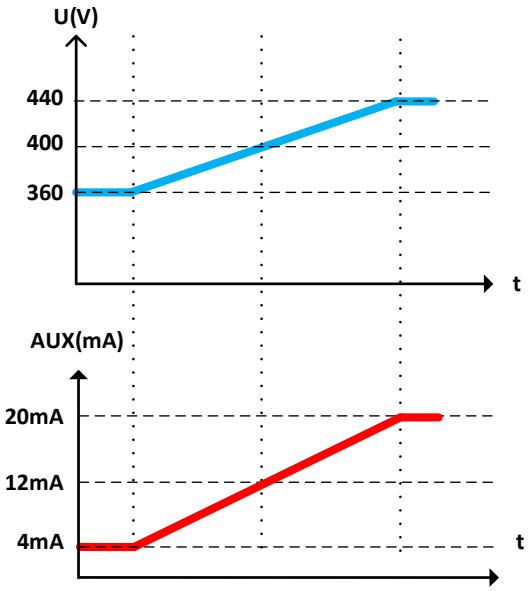
Type of signal interface is selected by setting parameter [P123] value as shown in table above. Remember that, if AUX input is ENABLED, EXT POT function is automatically DISABLED.

Parameter setting:	Signal type:	Connection:	Explanations:
[P123] = 1	±5Vdc input		-5Vdc / +5Vdc analogue signal connection. A1 internally connected to AVR GND. A2 signal is referenced to A1 potential (GND) connection.
[P123] = 2	4-20mA input		4mA / 20mA signal connection. A1 internally connected to AVR GND. A2 signal is referenced to A1 potential (GND) connection with 100Ω SHUNT impedance.
[P123] = 3	0-10Vdc input		0-10Vdc signal connection. A1 internally connected to AVR GND. A2 signal is referenced to A1 potential (GND) connection.

The effect of the AUX input signal on the AVR output voltage change can also be set. Therefore, 100% swing on the analogue input signal can only change the AVR output voltage with the limits set by parameter [P124] as shown in the table below:

Parameter number:	Parameter Description:	Units	Parameter limits:	Explanations:
[P124]	"AUX Input RANGE" selection	%	0 – 100 (default = 30)	Sets the limit change of AVR voltage reference with reference to AUX input signal

The function description is given in the table below. This example shows the effect of AUX control signal on the alternator output voltage with "AUX Input RANGE" limit set to 20% for a full 100% signal change across terminals A1 and A2:

Parameter setting:	Set Value:	Connection and control range:	Explanations:
[P123]	2		Parameter [P123] = 2 (AUX input set for 4-20mA signal type)
[P124]	20 (±10%)		Parameter [P124] = 20 (AUX input RANGE is set to ±10% affect for 100% change in the AUX input current signal value) (AVR output voltage is set to 400Vac nominal)

The control characteristics based on the AUX signal input is designed as a LINEAR relation such that the configured control range of the AUX signal input will change the AVR voltage reference in a linear manner. Same characteristics also apply to the trimmer pots on the AVR and their scan from minimum to maximum position reflects as a linear control on the voltage control function.

Notice that all “AUX & COMMUNICATION” signals are connected on the same galvanic system, while this group of terminals are galvanically isolated from the “POWER & SENSE” terminals group. Therefore, if the analogue inputs are connected to an external control system, check that it is safe to connect your PC to the AVR USB port.

5- PID Parameter Settings (Stability control):

DAVR90 is designed in digital control topology, using state-ot-the-art microcontroller technology and the overall dynamic performance of the AVR can be precisely set to perform in any application. To achieve this, user needs to set the PID parameter settings such that, AVR dynamic behaviour matches the alternator response characteristics as best as possible.

The following information walks the technical user of this manual through a set of practices to achieve the stability settings of the AVR unit for best performance operating on any alternator. The dynamic behaviour of the AVR together with the diesel engine can also be optimised and this is also shown in the related chapters of this manual.

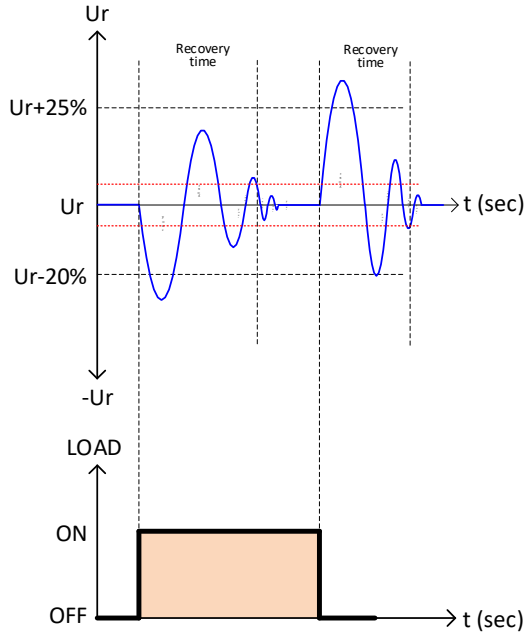
5.1: Understanding DAVR90 Dynamic Behaviour:

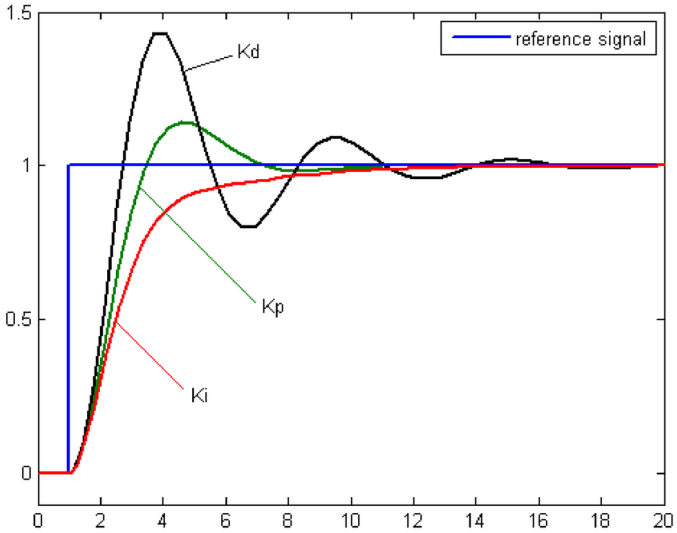
DAVR90 design is based on “Digital Control” technology where all the sensing signals are converted into digital values and processed at very high-speed during operation. Since the AVR is designed to be used on a wide range of alternator frames, the response characteristics of the AVR must be set to control the dynamic behaviour of the alternator type and this is mainly achieved by setting the PID coefficients as close as possible to the ideal values, required by the alternator.

In other words, by setting the correct PID coefficient values, you must optimise the following characteristics of the alternator:

- Steady-state regulation of the alternator stator voltage,
- Undershoot (maximum allowed voltage dip) characteristics of the alternator with sudden load application to the alternator,
- Overshoot (maximum allowed voltage rise) characteristics of the alternator with sudden load removal from the alternator,
- Recovery time in “seconds”,

General dynamic behaviour of a Generator set is shown in the graphics below:





The limits of the recovery time and the transient response levels are determined by ISO8528-5:2018 and user should set AVR PID and LAM parameters to ensure that overall generator can perform according to the required “G” class operational limits.

5.2: 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	Explanations:
[P140]	"STB" Trimmer pot effective range	%	0 – 30 (default = 30)	Changes the value of K_P as % of the value set by parameter [P110]

The PID parameter descriptions are given in the table below:

Parameter number:	Parameter Description:	Set limits	Explanations:
[P110]	Coefficient of Proportional K_P value	0 – 2048 (default = 425)	Proportional coefficient of the controller. Increasing it will cause faster AVR reaction but worse steady state stability.
[P111]	Coefficient of Integral K_I value	0 – 2048 (default = 250)	Integral coefficient of the controller. Increasing it will cause better steady state stability but worse reaction time.
[P112]	Coefficient of Differential K_D value	0 – 2048 (default = 125)	Derivative coefficient of the controller. Increasing it will cause faster AVR reaction but worse steady state stability.

5.3: 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.

5.4: 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.

5.5: 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.

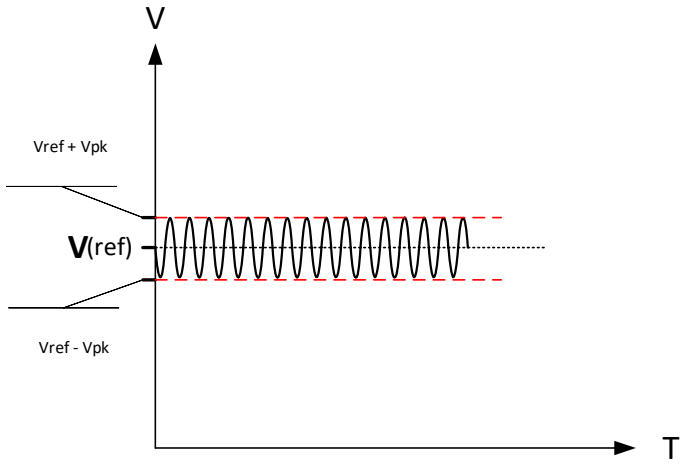
Low value settings will reduce the system response time to sudden load changes on the alternator. The value of differential coefficient must be set together with the integral and proportional coefficient values to get the best performance characteristics.

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 DAVR90 to start fine tuning the values to get best dynamic performance with the alternator,

5.6: 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:	Explanations:
Steady-State Voltage Regulation	%		V(ref) ±0.25% (specified ripple factor)

As an example, if stator voltage reference value is set to 400Vac, then the AVR is capable of achieving a steady-state voltage regulation with a ripple factor, less than ±1Vpk-pk. Based on the "Dynamic" behaviour of the alternator characteristics, it is required to tune the PID constants of the AVR.

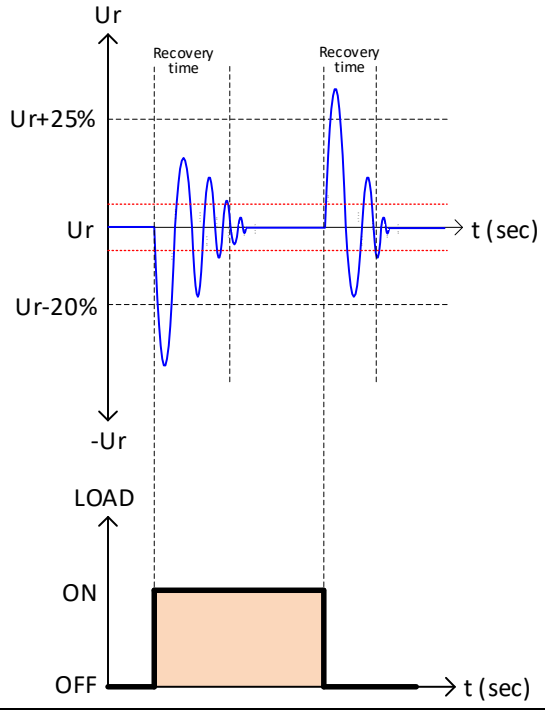
5.7 Reference Change "Ramp Limit" function:

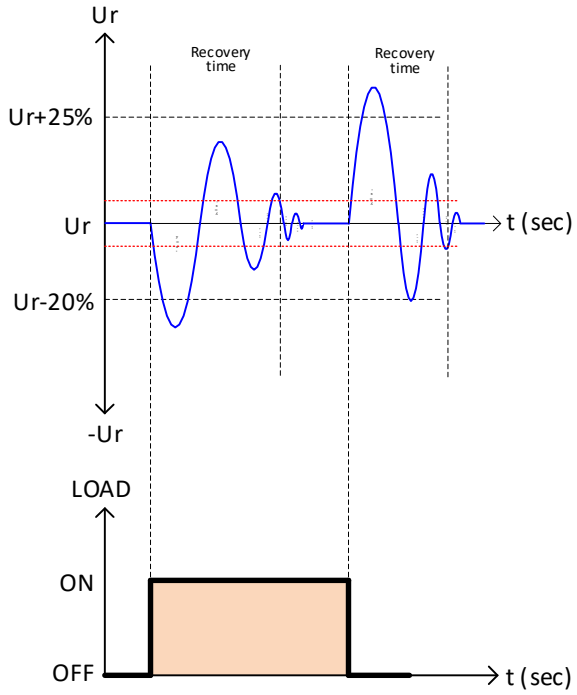
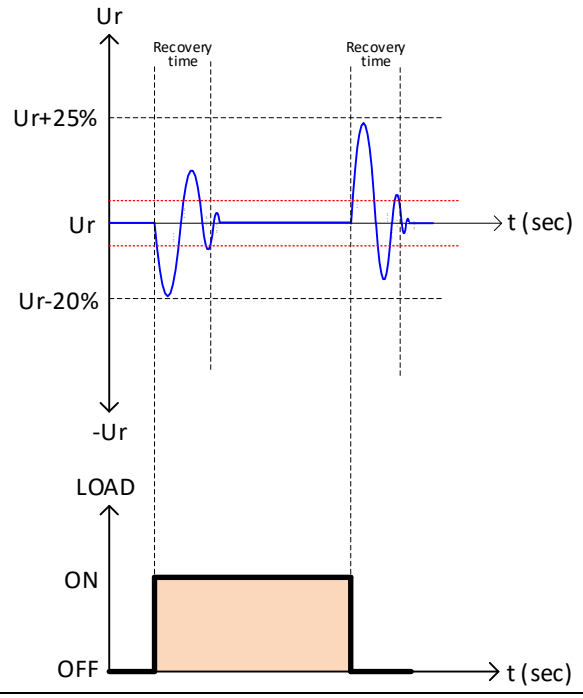
When changing the voltage reference either from software or using VLT pot on the AVR or using the EXTERNAL Pot, it is possible to smooth the voltage change response, with respect to the unit change in reference regulation voltage value, so that the alternator stator voltage has smooth and stable delayed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

Parameter number:	Parameter Description:	Units	Parameter set limits	Explanations:
[P107]	Reference Change RAMP limit function	V/s	1 – 100 (default = 50)	Sets some time delay while changing the voltage reference value of the AVR

5.8: 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)	

5.9: Management of set PID parameters:

DAVR90 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 Tool" allows the user to save the parameter sets for any particular 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- "Block Load Acceptance" (LAM) Parameter Settings:

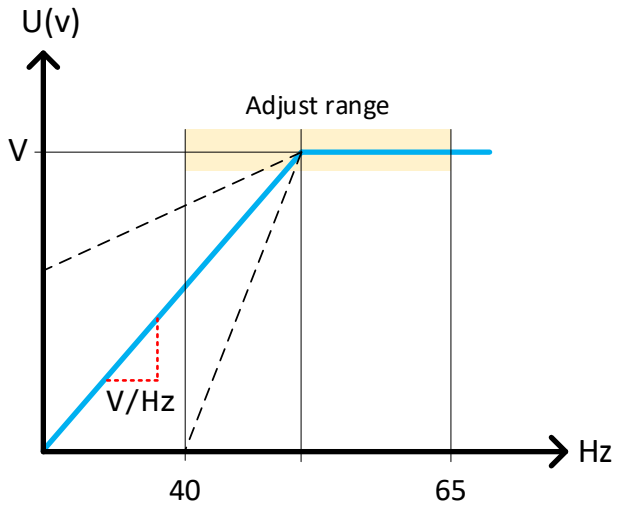
DAVR90 has complex algorithms to allow excellent performance when the generator is subjected to sudden block loads. Based on the engine response characteristics with high block load application, DAVR90 behaviour can be set to ease the burden on the diesel engine and improve generator's total recovery time considerably.

By setting the parameters carefully, it is possible to down-size the prime mover to handle high-power block load applications and yet stay within ISO8528 standard operating limits. The LAM control parameters are given below and explained in detail in the following chapters:

- UFRO Knee point [P117]
- DIP rate [P118]
- DWELL recovery duration [P119]
- LAM mode selection [P120]

6.1: Setting UFRO parameters:

In order to protect alternator excitation system, based on the speed of the prime mover, DAVR90 AVR unit can be configured to reduce the excitation 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	Explanations:
[P117]	UFRO Knee Point (Hz)	40 – 65 (default is 48)	
[P118]	DIP Rate (dV1/df) V/Hz	0 – 80 (default is 8)	

UFRO knee point is the frequency threshold level, where the voltage starts to dip with respect to unit change in frequency and this value is set by parameter [P117]. This parameter can be set within the limits 40Hz to 65Hz. Factory default value of parameter [P117] is set to 48Hz (for a 50Hz system) and can be changed, if required.

This parameter value should be set according to the engine response characteristics and the speed governor performance. If engine has a fast response characteristic to recover from a sudden block load application, [P117] can be set to a lower value. If engine is slow to recover, [P117] can be set closer to the nominal operating frequency to allow the voltage to dip with small frequency reduction against a sudden load, hence reducing the load burden on the engine.

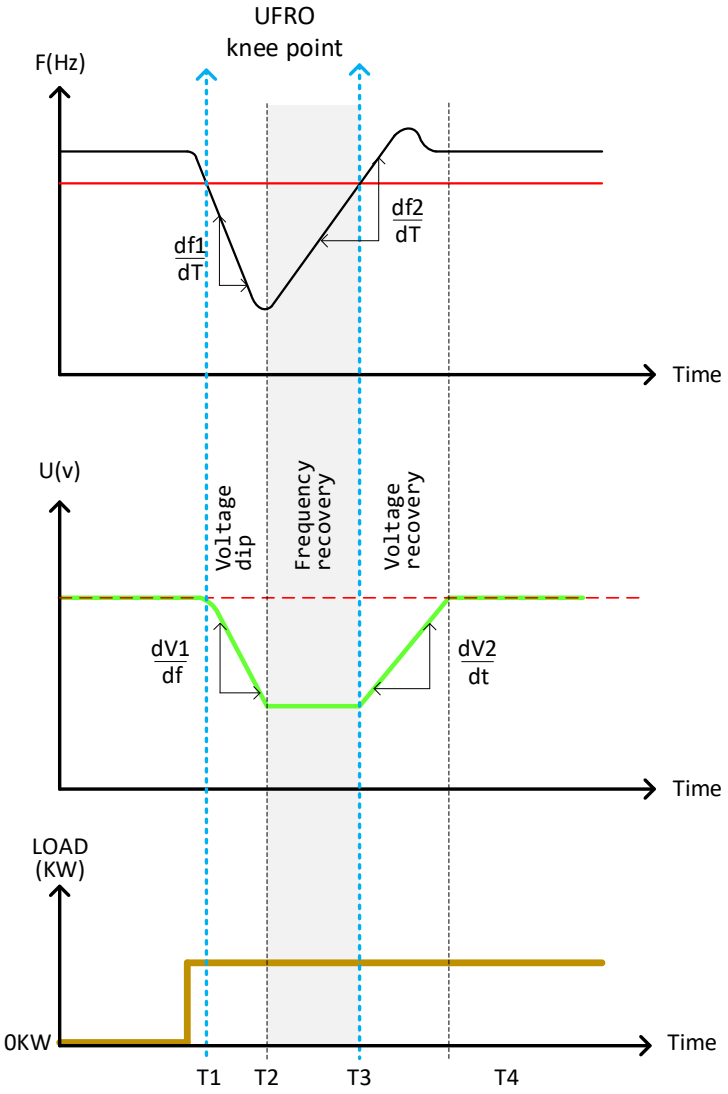
Once reached at UFRO roll-off point in frequency, DAVR90 will start to control the internal voltage reference point to reduce the alternator stator voltage at a rate set by parameter [P118]. This parameter will determine the rate of reduction in voltage as a function of reduction in frequency.

User should set this parameter according to the prime mover capacity and the application requirements. [P118] can be set in a range of 0V/Hz to 80V/Hz, and this value will determine how fast the voltage dips, when a sudden load is applied to the generator. The parameter details are shown in the above table, and the parameter factory default setting is set for 8.0V/Hz reduction in stator voltage.

6.2: Setting "Load Acceptance" (LAM) operation mode:

LAM function is designed to increase the recovery capacity of the generator, when a sudden block load is applied. 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 load burden state.

"LAM function parameters allow the user to precisely set the behaviour of the generator, according to the required sudden block load recovery requirement 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:



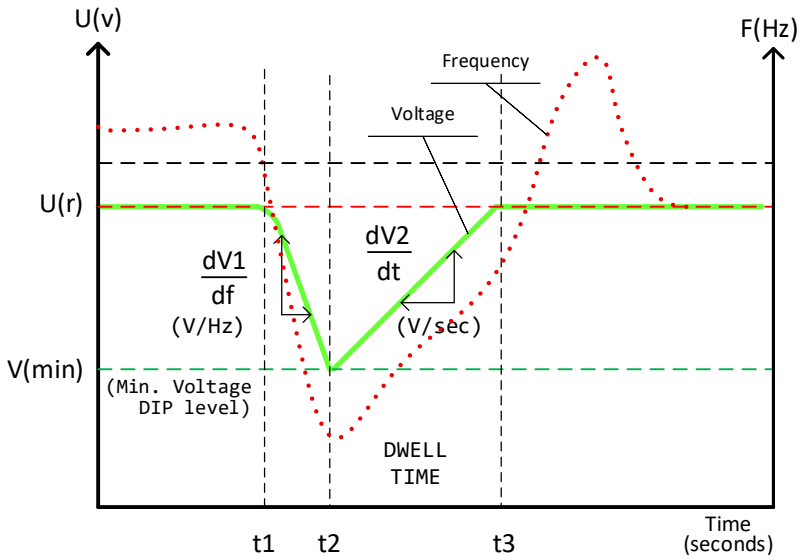
Setting “Dip Rate” parameter [P118] = 0 will cancel the function, means that there will be no voltage reduction per change in generator frequency, when block load is applied to the generator. When load is applied to the generator, AVR will try to keep the alternator voltage according to the set regulation 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 engine limits.

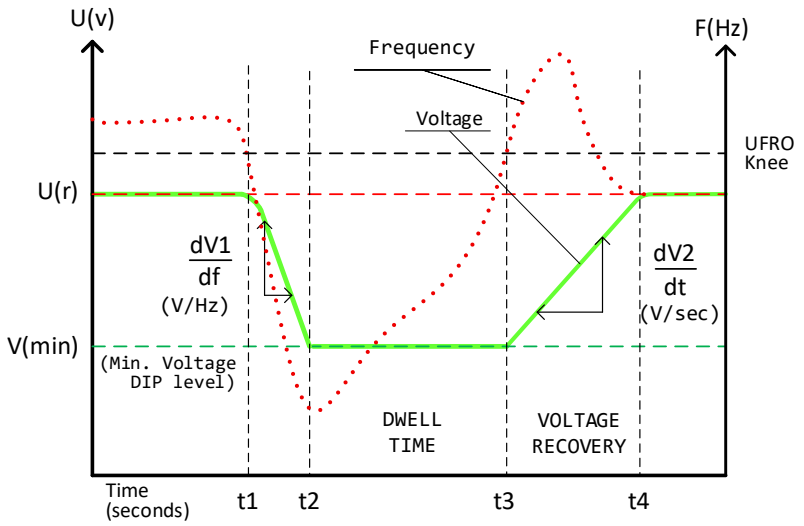
LAM operation mode is selected with parameter [P120] and user can either select “NORMAL” operation or “ENHANCED” operation mode characteristics, based on their engine type and application requirements. Setting [P120] = 0 will select the “NORMAL” operation mode and in this mode, voltage starts to recover as soon as the frequency starts to increase (frequency gradient changes to positive). This will allow the voltage to recover quickly but puts a heavier burden on the engine. The rate of voltage rise (recovering from dip state) is set with parameter [P119], which determines the time (dV2/dt) the alternator voltage recovers back to its set normal reference value.

6.2.1: Setting DWELL (Relaxation) parameters:

To set the recovery characteristics following a voltage DIP condition, it is required to set the characteristics of the voltage to recover back to its nominal set regulation reference value. In other words, the slope of recovery characteristics must also be set to define how quickly the voltage will rise 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. DAVR90 allows two different recovery characteristics, which can be set by parameter [P120], and the detailed operation is shown in table below:

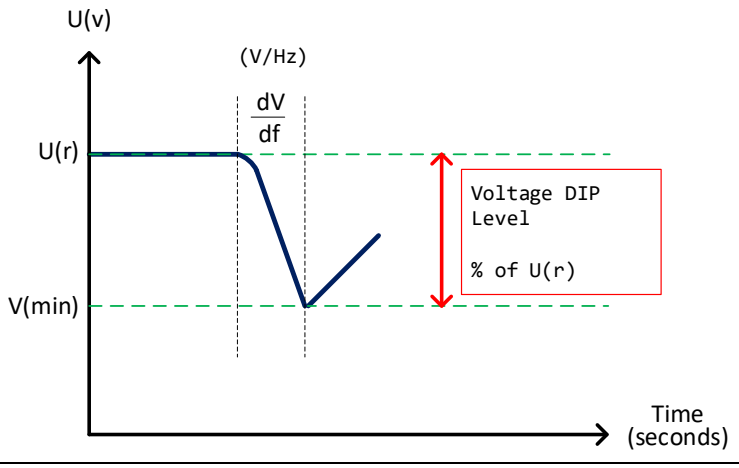
Parameter number:	Parameter Description	Set limits	Explanations:
[P119]	DWELL Time setting (+dV2/dt) V/sec	0 – 480 (default is [0])	
[P120]	LAM Mode Selection (NO-DELAY mode)	**[P120] = 0** **(Normal mode)**	

Parameter number:	Parameter Description	Set limits	Explanations:
[P119]	DWELL Time setting (+dV2/dT) V/sec	0 – 480 (default is [0])	
[P120]	LAM Mode Selection (DELAY Mode)	[P120] = 1 (Enhanced mode)	

[P119] should be set according to recovery capability of the prime mover following a sudden block load application. Default value is set to [0] at the factory. This corresponds to no voltage recovery until the selected state of [P120] meets the selected operation mode conditions.

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” class 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 limit level, parameter [P109] needs to be configured. The parameter details are explained in the table below:

Parameter number:	Parameter Description	Set limits	Explanations:
[P109]	Minimum reference percentage (% of U(r))	0 – 100 (default = 75)	

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, DAVR90 will try to maintain the minimum DIP voltage level at 200Vac even if the frequency drop exceeds the “DIP Rate” determined voltage level.

6.3: Further explanations on LAM operation mode selection [P120]:

Selecting the correct LAM operation mode is effective in the final performance of the generator. “NORMAL” operation mode selection [P120 = 0] sets the AVR to start restoring the alternator voltage, as soon as the gradient of frequency response turns positive. In this case, AVR will start to control the voltage recover behavior, based on the parameter [P119] set value. If the prime mover can recover quickly after block load application, this operation mode will recover the alternator voltage with minimum time delay.

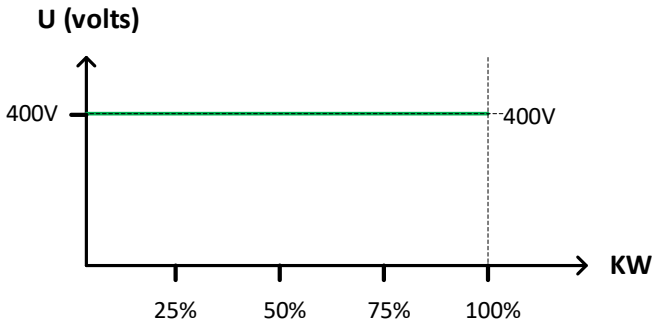
If LAM operation mode is selected as “ENHANCED” mode, then the AVR will wait at the minimum voltage reference value until the prime mover recovers, and the frequency hits the UFRO Knee point value. Only then will the voltage start to rise, based on the selected value of parameter [P119]. During this time interval, AVR will delay its DWELL start time and will control the rate of voltage rise according to parameter [P119].

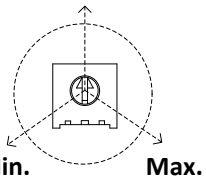
7- "Droop" Parameter Settings:

DAVR90 AVR unit has integrated CT for measuring the alternator load current and based on phase angle and magnitude of the stator current vector, it can perform reactive load compensation and resistive line drop compensation. The operation mode can be set with parameter number [P137] and the effective adjustment range of the on-board DROOP trimmer can be set with parameter number [P141].

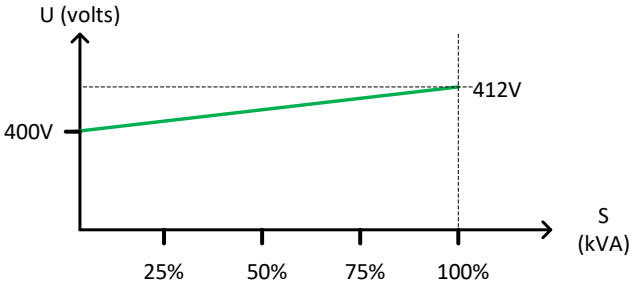
<table>
<tr><th>Parameter Number:</th><th>Setting Range:</th><th>LINE VOLTAGE DROP COMPENSATION</th><th>DRP POT Setting</th></tr>
<tr><td>[P137] = 0
[P141] = 0

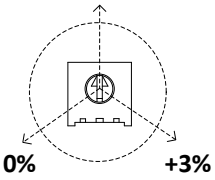
(DROOP function Disabled)</td><td rowspan="3">[P137] (0 – 3)
Default = 0

[P141] (0 – 10)
Default = 6</td><td> 

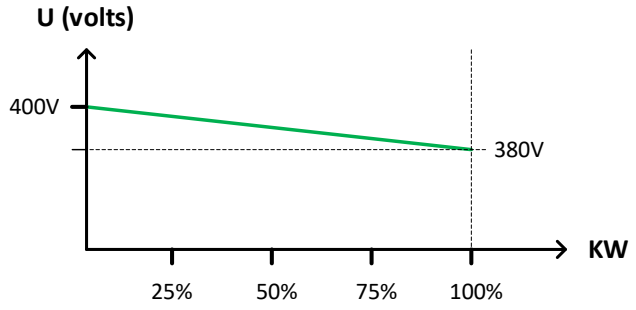
(No compensation based on the stator load current)</td><td> 

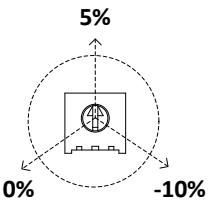
"DRP" Pot disabled.</td></tr>
<tr><td>[P137] = 1
[P141] = 3

(LINE DROP Compensation set for 3%)</td><td> 

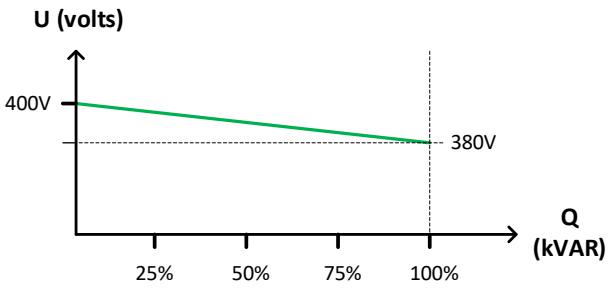
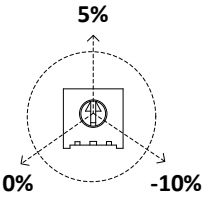
(LINE DROP compensation mode enabled)</td><td> 

"DRP" Pot set for LINE DROP compensation</td></tr>
<tr><td>[P137] = 2
[P141] = 10

(LOAD BALANCE Compensation set for 10%)</td><td> 

(LOAD BALANCE compensation mode enabled)</td><td> 

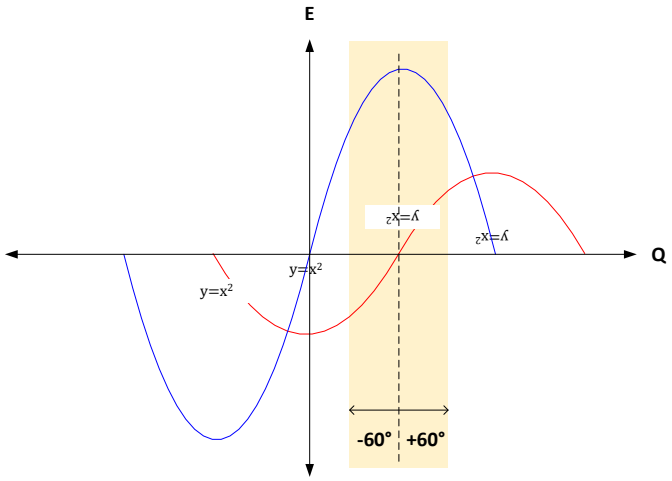
"DRP" Pot set for LOAD BALANCE compensation</td></tr>
</table>

[P137] = 3 [P141] = 10 (REACTIVE DROOP Compensation set for 10%)	[P137] (0 – 3) [P141] (0 – 10)	 (QUARATURE DROOP compensation mode enabled)	 “DRP” Pot set for REACTIVE DROOP Compensation

If “LOAD BALANCE” mode is selected ([P137] = 2), DAVR90 calculates the stator load magnitude and compensates the set “Voltage Reference” of the AVR to release the load burden on the Generator. This is particularly practical if the Generator is feeding high-motor-load, and the prime mover can relax to feed the load without tripping the secondary protection devices.

7.1: “Droop” Phase Compensation:

In applications where many generators are connected to the same busbar, the reactive component from each generator is equally shared by the number of generators on the same busbar. When different power rated and/or different brand generators are connected to the same busbar, it may sometimes require correcting the phase angle of the reactive component on the CT measured current vector. On DAVR90 AVR unit, this can be achieved by setting the correct phase angle so that each AVR can precisely compensate for the phase- angle error and hence share the reactive load equally and more precisely. The parameter definition is shown in the table below:

Parameter Number:	Parameter Description	Setting limits	Explanations:
[P138]	DROOP Phase compensation	0 – 1200 (±0° to ±60°) Default = 600 (±30°)	

8- AVR "START SEQUENCE" Control:

DAVR90 AVR 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.

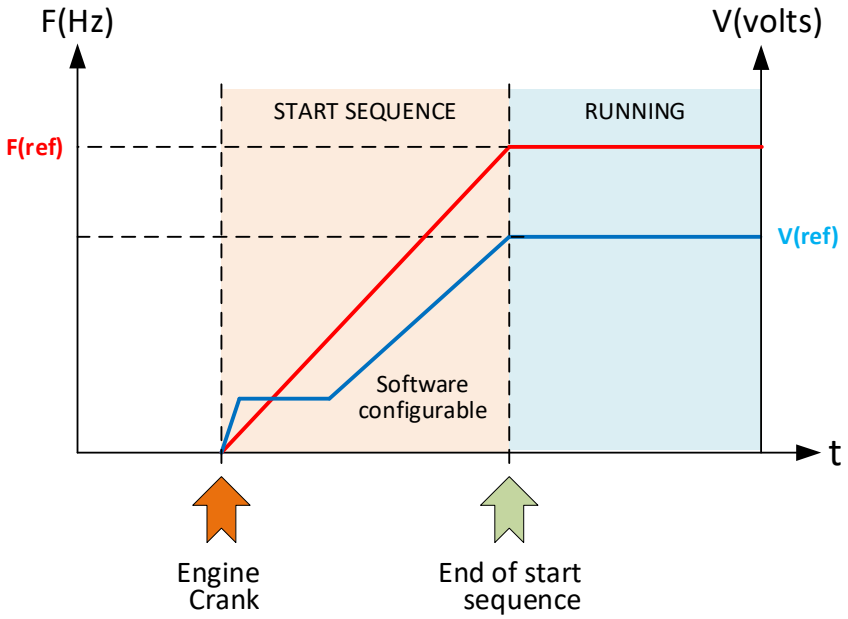
The "Starting Frequency" is measured from the sense input terminals and ensures that the generator reaches a stable operating speed before voltage regulation begins. The "Starting Time Delay" allows further control by introducing a timed wait after the frequency threshold is met. This delay can be useful 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 must be set by the user to define the start characteristics of the alternator, referenced to the prime mover's operation. Alternator residual voltage seen across P1, P2 and P3 power input terminals must be 6Vac minimum to be able to automatically start the voltage build-up on alternator stator windings. If the residual voltage is less than 6Vac, then the AVR may not have enough energy to start excitation, in this case the excitation winding needs to be flashed momentarily with a 9V battery, connected in the correct polarity to F-and F+ terminals.

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 meet wide range of demands 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 DAVR90 suitable for special applications, where the prime mover cannot start immediately like the classic diesel engines.

“Start Sequence” 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 a re described in more detail below:

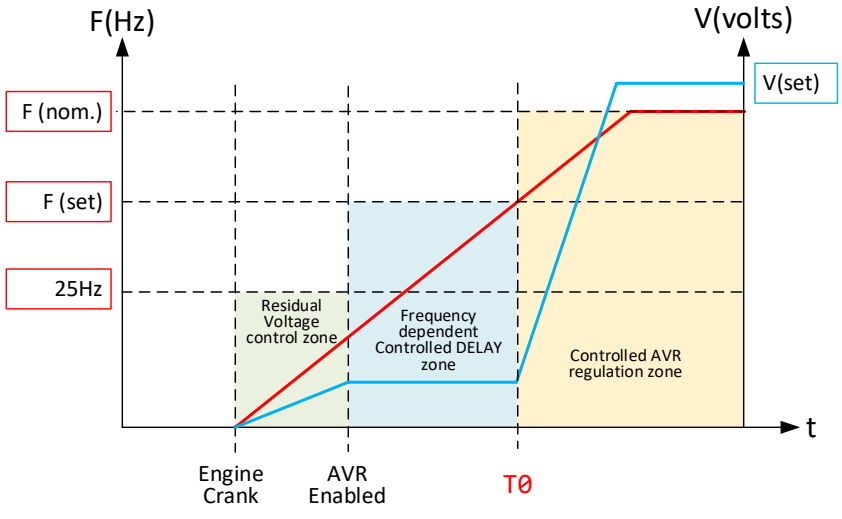
8.1: “Starting Frequency” Delay function:

DAVR90 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 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.

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

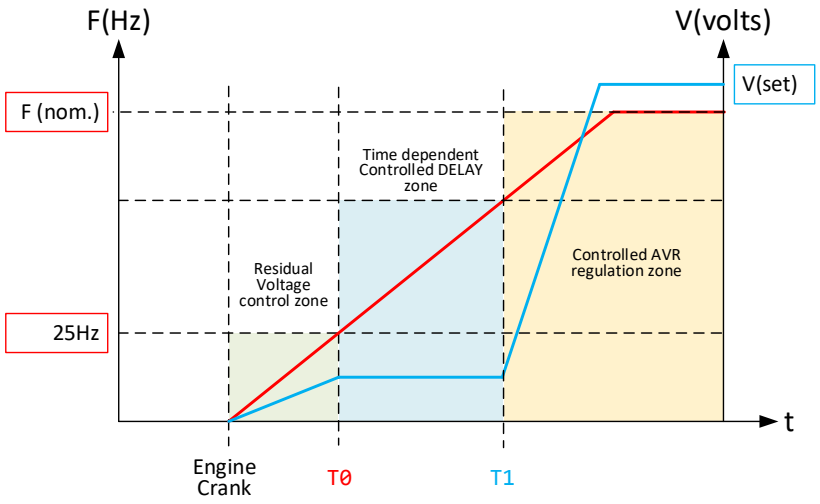
Parameter Number:	Parameter Description	Setting limits	Graphical presentation:
[P105]	START FREQUENCY Delay control function	25 - 75 (Hertz) (Default = 25)	

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, P2 and P3 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.

8.2: "Start Time Delay" Function:

Once the STARTING 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= 0	

"START TIME DELAY" parameter can be set between 0 sec. to 7200 sec. time duration. The timing will start (T0) after the START FREQUENCY value is reached by the prime mover. Until the end of "start delay" time, DAVR90 will regulate the alternator phase voltage at around 60Vac. This is required to power its own hardware circuit inside the AVR. If the residual voltage is higher than this value at the prime mover "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.

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.

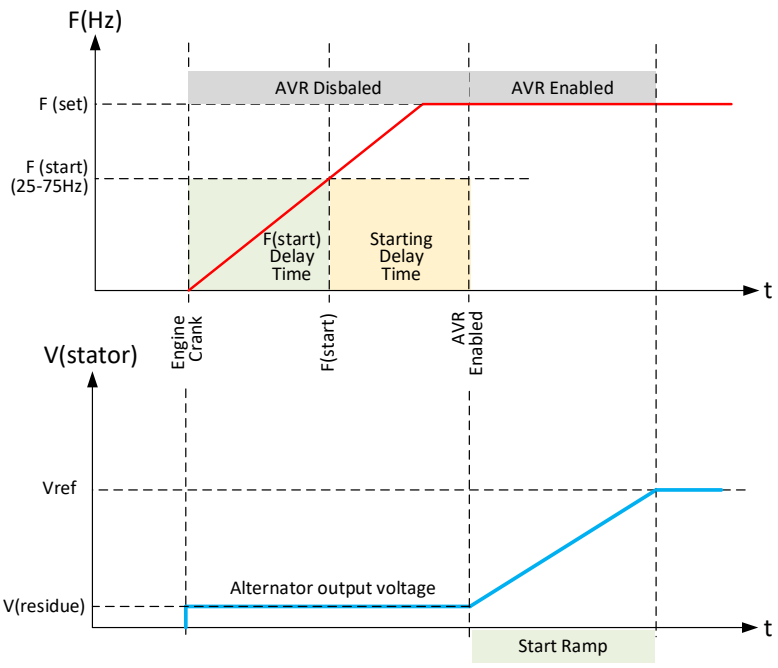
8.3: “Soft Start Ramp” Function:

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, 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 behavior, especially when operating in parallel with other generators or supplying sensitive loads.

SOFTSTART 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 is explained in more detail in the table below:

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

8.4: "Auto-Start" Enable/Disable:

DAVR90 has a control parameter to allow the excitation to either start AUTOMATICALLY or wait for an external "START" Signal from an external device or from the START parameter setting internally. To control the Auto-Start function, parameter [P102] can be used. Detailed parameter description is given in the table below:

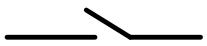
Parameter Number:	Parameter Description:	Setting limits	Explanations:
[P102]	AVR AUTO-START control parameter	[P102] = 0 (Disabled) Default = 0	AVR in "HALT" state
		[P102] = 1 (Enabled)	AVR in "RUN" mode (if the alternator is running and there are no alarm conditions)

8.5: "External Start/Stop" Control function:

("Remote Start" & "Remote Stop" Control Function for DAVR90)

The DAVR90 can be controlled externally with an external control signal from peripheral control devices. In this mode, AVR excitation output can be forced into "HALT" status, until a "START" or "STOP" signal is sent from an external control device to the AVR unit.

As outlined in previous sections, DAVR90 is fitted with two "Temperature Measurement" inputs, which can also be set as "Digital Input" via parameter setting. Each of the configurable inputs (T1-T2) and (T3-T4) can be set as a "digital input" and configured by pre-set functions. "External Start" or "External Stop" signal is applied via external potential-free relay contact across one of the three digital input terminals. Applying a "closed contact" to one of the digital inputs (shorting the terminals with an external dry contact) activates that function (TRUE). The operation is shown in the table below:

Parameter Setting:	Parameter Description:	External control input	Explanations:
[P102] = 0	"AUTO-START" Disabled Default setting	 (T1-T2) (T3-T4)	Remote Start / Stop "FALSE"
		 (T1-T2) (T3-T4)	Remote Start / Stop "TRUE"

The details of "Auxiliary Input Configuration" functions will be explained in the next chapter.

8.6: Manual "Start Control" with parameter setting:

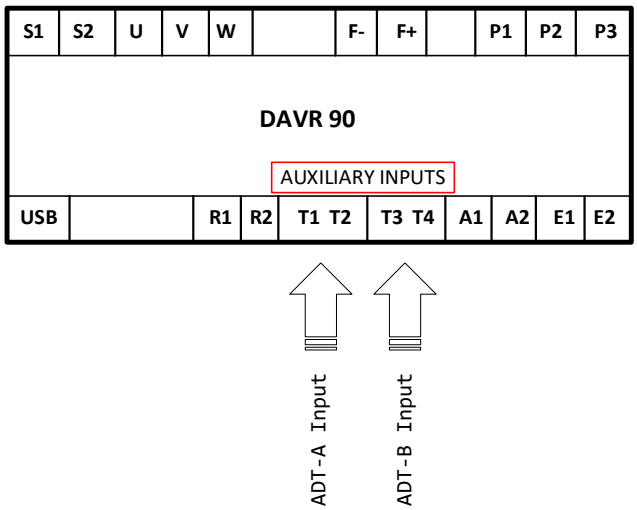
It is possible to "START" or "STOP" AVR functioning manually, by setting parameter [P101] from the PC-Tools menu. This parameter also indicates if there has been an automatic HALT due to an alarm state of the AVR. Parameter function is described in the table below:

Parameter Number:	Parameter Description:	Setting limits	Explanations:
[P101]	AVR START status control parameter	[P101] = 0 (STOP) Default = 0	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.

9-Configuration of AUXILIARY Inputs:

DAVR90 is designed with 2 ADT inputs (Analogue/Digital/Temperature) and the characteristics of these inputs can be configured according to user requirements. AUXILIARY inputs are shown below



There are various options which the user can choose from, and these options are shown in the table below:

Parameter Number:	Parameter Description:	Setting options for [P270], [P277] and [P284]	Explanations:
[P270]	ADT – A input	**0** = Disabled ***1** = Analogue type input (CANBUS, MODBUS only)* ***2** = Digital type input (CANBUS, MODBUS only)* **3** = Winding temperature input **4** = Auxiliary temperature input **5** = External START **6** = External STOP	ADT – A input (terminals T1 and T2) ADT – B input (terminals T3 and T4)
[P271]	Monitoring only		
[P272]			
[P277]	ADT – B input		
[P278]	Monitoring only		
[P279]			

Any of the AUXILIARY inputs can be set to have certain pre-determined characteristics as described in the above table. If temperature is going to be measured, only RTD type temperature sensors can be used and detailed configuration and calibration can be executed in the PC-Tools software menu.

If any of the “ADT” input is set to “0”, this action will disable the AUX channel, and the microcontroller will not read any values from this channel. It will be good practice to disable (set [P270] and/or [P277] to “0”) any AUX channel, which is not going to be used in the application.

If one of the AUX channels is set to “1”, this will set the channel to read an “Analogue Signal” connected to the selected AUX terminals of the AVR. This mode is only available for MODBUS use, and more data is available in PC-Tools SW package on how to configure the set up for analogue data transmission.

If a “Digital input” signal is to be connected to the AUX terminals, then respective channel parameter must be set to “2” and in this case, a dry-contact digital input (potential-free contact input) can be detected by the AVR unit. This input can be linked to certain functions in the AVR, using PC-Tools SW menu.

AUX inputs can be used to measure the winding temperature on the alternator. If required, an external temperature point can also be read by the AVR, when connected to a Pt100 temperature sensor. Certain functions can be linked to this input and limits can be set for alarm or AVR shut-off function.

Setting AUX parameter to “5” or “6” can control the AVR excitation from a remote device. A dry-contact input is required to activate the function, based on the selected configuration. Remember that the function will only be “TRUE” if the selected AUX terminal has a short-circuit across its terminals, otherwise it is a “FALSE” state input.

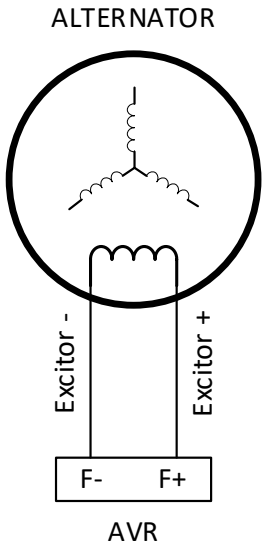
The data registers at [P271] and [P272] for ADT-A input channel and [P278] and [P279] for ADT-B input channels are “read-only” registers. When connected to the PC-Tools SW package, users can monitor these registers and track the activity on the AUX channel inputs.

10- “Field Winding” connection (Alternator EXCITATION):

DAVR90 is designed to pick up 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, P2 and P3 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 20 - 25Hz (600rpm for a 1500rpm generator system) based on the set configuration parameters. 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.

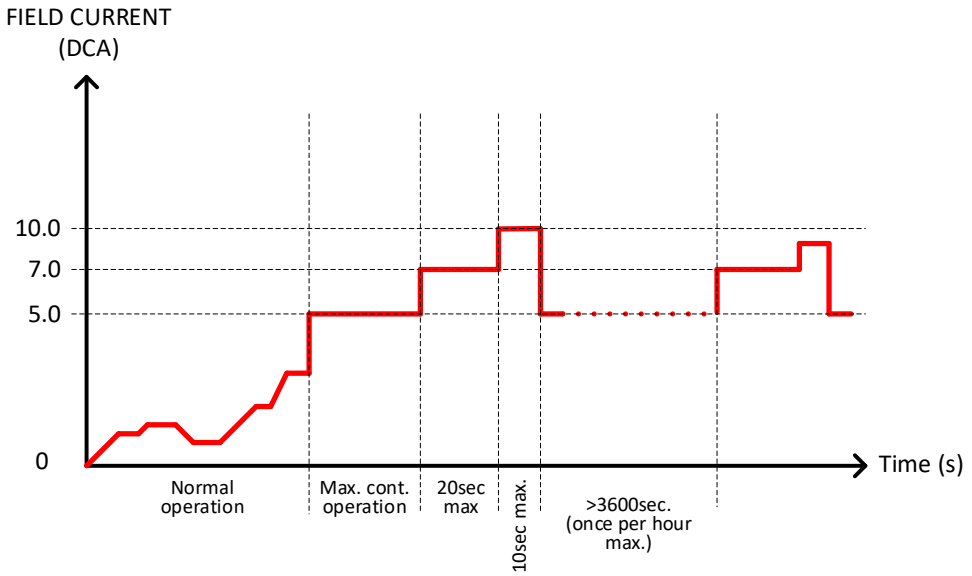
If SHUNT or AUXILIARY power connection configuration is selected, make sure that the voltage limit is not exceeded across the power terminals of the AVR. Exceeding the limits can jeopardise the line capacitor operating lifetime on the AVR. For this connection type, P1 and P2 terminals are used on the AVR unit.

DAVR90 has IGBT controlled drive for FIELD winding and can deliver up to 10Adc for limited period. Under standard operating limits, the unit can deliver 5Adc continuous 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.

10.1 FIELD drive current capacity:

DAVR90 has a continuous FIELD drive capacity of 5.0Adc under specified conditions. In order to be able to get full FIELD power from the AVR, it is mandatory to meet the specified operating conditions. Field drive capacities are shown in table below:

DAVR90 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.

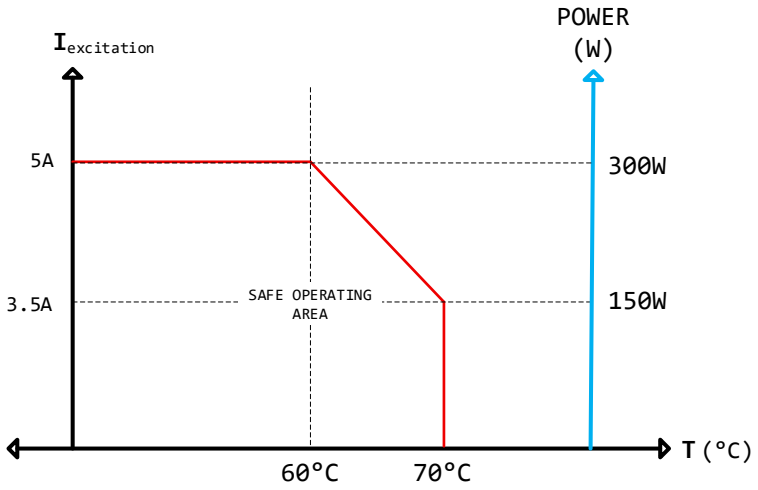
FIELD Overexcitation function is designed to calculate the thermal build-up energy in the FIELD winding and the function is based on the IDMT operation curve characteristics of fuse operation. In this function, the AVR measures the magnitude of the Excitation current and integrates this value against 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.

10.2: "Safe Operating Area" and "Excitation Power" Limit:

DAVR90 can deliver continuous 5.0Adc and momentary 10.0Adc into the excitation winding under specified operating conditions. Instantaneous excitation power is limited with the hardware circuit of the driver stage and also with the thermal cooling capacity of the heatsink.

To be able to operate within the safe limits of the device, specified voltage and current limits should not be exceeded and at the same time, thermal cooling capacity of the device should stay within the safe limits. Based on the maximum allowed power input voltage limits and the excitation impedance range, continuous power dissipation must not exceed the SOA limits for safe operation. Continuous SOA limits are given in the graphics below:



DAVR90 can deliver full 300W power into the excitation winding under continuous operating conditions up to 60°C ambient temperature limit. Above this temperature level, continuous excitation power is derated according to the SOA graphic given above. From 60°C to 70°C ambient conditions, excitation power must be derated by -5%/°C linearly up to 70°C, which is the maximum operating temperature limit of the AVR unit.

Given these operating conditions, DAVR90 is capable of delivering 7.0Adc for 20 seconds and 10.0Adc for 10 seconds as specified in the user manual.

The above information is given as installation guide for DAVR90 unit. Provided that the ventilation of the installed location of the AVR and operating ambient temperature conditions are suitable, it is possible to get more excitation power from the AVR ($P_{EXCITATION}$ > 300W), provided that the maximum excitation current limit of 10.0Adc and maximum allowed voltage input voltage limits of 300Vac are not exceed at any time during operation.

For guidance, it is possible to determine the continuous power limit of DAVR90 using the formula below:

$$P_{EXCITATION}(W) = (I_{FILED})^2 \text{ X } R_{FIELD} = 300W \text{ (max.)}$$

The above formula gives the maximum power limit in continuous operation, based on the FIELD winding impedance of the alternator.

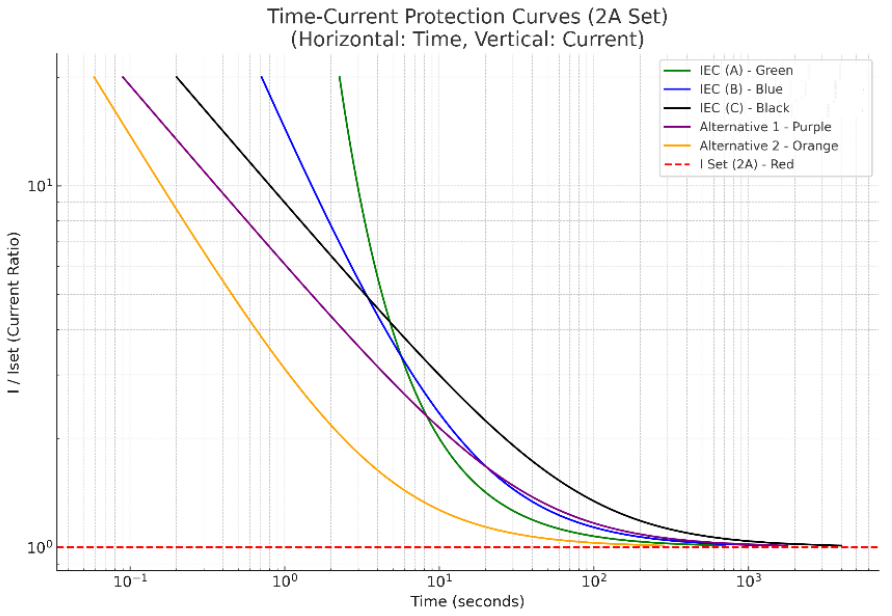
10.3: IDMT Curve protection:

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 carefully calculated and fitted with the IDMT curve type, selected by the user from the configuration parameter menu. With this method, DAVR90 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 curve calculation can be selected according to the standards, as explained in the table below:



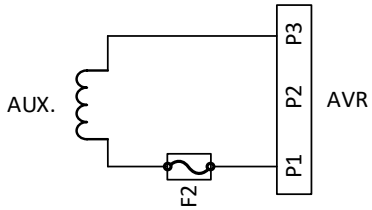
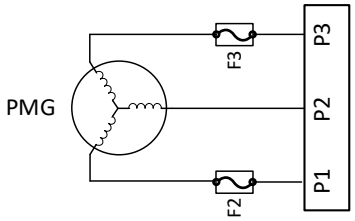
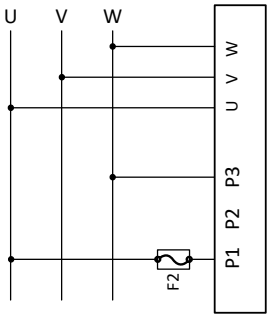
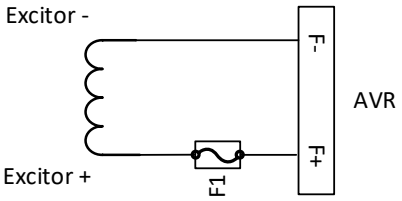
Line colour	Curve	T	k	∝
Green	IEC Standard Inverse curve A	1	0.140	0.02
Blue	IEC very Inverse curve B	1	13.5	1
Black	IEC Extremely Inverse curve C	1	80	2
Purple	Alternative curve A	0.449	80	2
Orange	Alternative curve B	28.57	0.140	1.4142

Function Description:	Parameter set limits	Explanations:
IDMT Field Current Sense mode	(only **“IEC Standard Inverse-A”** curve is available)	(IEC Standard Inverse-A protection curve characteristics, not user selectable)

10.4 Fuse protection:

DAVR90 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.

If PMG is used, fuse protection is required for each phase of the power input. Please refer to the fuse table below for reference. In SHUNT and AUX connection mode, since the POWER to AVR is fed from single phase, a suitable fuse MUST be used in the power feed line. Suitable fuse ratings are given in the table below.

AVR FUSE rating (must be used externally)	FUSE connection schematics
6.3A (“fast acting” type fuse) (AUX winding connected protection with maximum fuse rating value, if required, a smaller rated fuse can be used)	
6.3A (“fast acting” type fuse) (PMG connected protection with maximum fuse rating value, if required, a smaller rated fuse can be used)	
6.3A (“fast acting” type fuse) (SHUNT winding connected protection with maximum fuse rating value, if required, a smaller rated fuse can be used)	
12A (“fast acting” type fuse) (FIELD protection with maximum fuse rating value, if required, a smaller rated fuse can be used)	

	To comply to UL safety standards, a suitable fuse protection is required in the cable harness. A suitable fuse protection MUST be used with DAVR90 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.

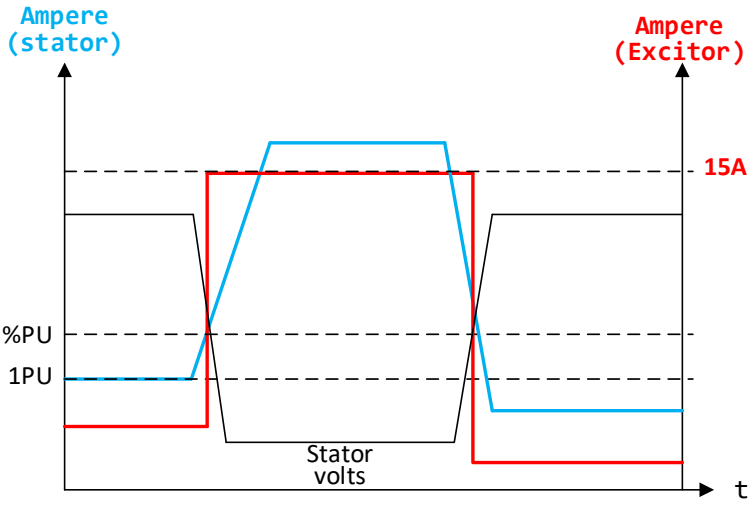
11- Setting the protection functions on DAVR90:

DAVR90 has a wide range of protection functions, which the user can set and configure according to their specific requirements. The AVR comes with a set of factory default setting values, but it is highly recommended that each protection function on DAVR90 is revisited and set carefully to fulfill the required operating characteristics.

11.1: Alternator "Short Circuit" Threshold:

DAVR90 can supply sustained Excitation current to the FIELD winding of the alternator to maintain overload feed conditions during sudden high-load application to the generator. Based on the selected parameter settings, DAVR90 calculates the short circuit PU magnitude and measures the stator load during high-load application to the generator.

To be able to supply the required excitation power to the alternator, parameter [P121] must be set according to application limits and any stator current measured above this "Threshold Current Limit" will be considered as "Short-Circuit" and the AVR will carry on supplying Excitation power to the alternator for a certain (programmed) period of time. During this operation, AVR protection functions like LoS, GCL and GUV protections will be disabled. Function description and parameter settings are explained in the table below:

Parameter number:	Parameter Description	Units	Parameter set limits	Explanations:
[P121]	AVR "SHORT CIRCUIT THRESHOLD" limit	mA	1000 – 10000 (integer value)	Sets the "short circuit" limit on the AVR as measured CT current value (based on PU calculation)
				

Setting [P121] is particularly critical if the alternator is going to deliver sustained short circuit power into the excitation winding when the alternator is momentarily loaded, like starting a high-power induction motor. In this case, since power is required to the excitor under high-load conditions, the power to AVR must be supplied either from an AUXILIARLY power winding or from a PMG unit. SHUNT connection in this case may have poor performance as the stator voltage is also expected to dip during sudden high-load application.

[P121] is set according to the PU ampere value of the CT on the alternator. Therefore, if the CT current ratio is X/5 on the alternator, then set [P121] = 7500 which corresponds to 1.5PU of the stator load current. In this case, the AVR will consider that alternator is under short circuit conditions if the measured current exceeds 1.5PU value and keep maintaining the excitation current to the excitor winding for a programmed time duration.

11.2: Setting the RELAY:

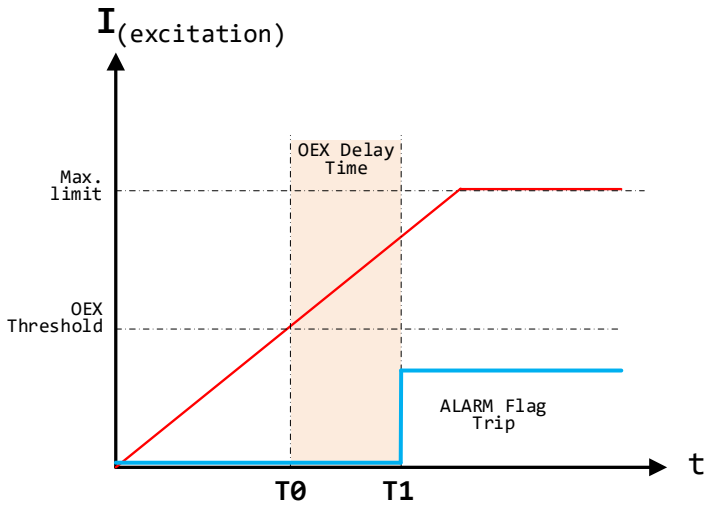
The “Alarm” relay on DAVR90 has a SPST dry contact output and can be triggered if any of the selected alarm is in the “TRUE” state. Linking the alarm relay to any one of the alarm conditions monitored and detected within the AVR is set in the PC-Tools Software menu.

The RELAY normal position (when there is no TRUE alarm condition) can be set from the configuration menu according to the table below:

Parameter Number:	Parameter Description	Units	Parameter Limits	Explanations:
[P150]	RELAY normal position	-	0 = N/O 1 = N/C	If set to “0”, then the relay is “de-energized” if there is no TRUE alarm condition, this is default setting, If set to “1”, then the relay is “energized” if there is no TRUE alarm condition,

11.3: OEX protection function:

Over-excitation protection function monitors the excitation current level and triggers a FLAG and an internal delay timer. If the OEX level stays above the trigger threshold level, the alarm will trigger after the delay time register is reached its set value. The function can be linked to activate the relay if set in the configuration menu. The function details are shown in the table below:

Parameter Number:	Parameter Description	Units	Parameter Limits	Graphical presentation:
[P400]	OEX Threshold	Amp.	0 - 10	
[P402]	OEX Delay time	Sec.	0 - 10	
[P406]	OEX RELAY	-	[P406] = 0	Relay is DISABLED
		-	[P406] = 1	Relay is ENABLED (default setting)

OEX protection function runs the IDMT thermal protection function in the background and cannot be disabled. This function continuously calculates the thermal model of the EXCITOR winding and together with the OEX parameters explained above.

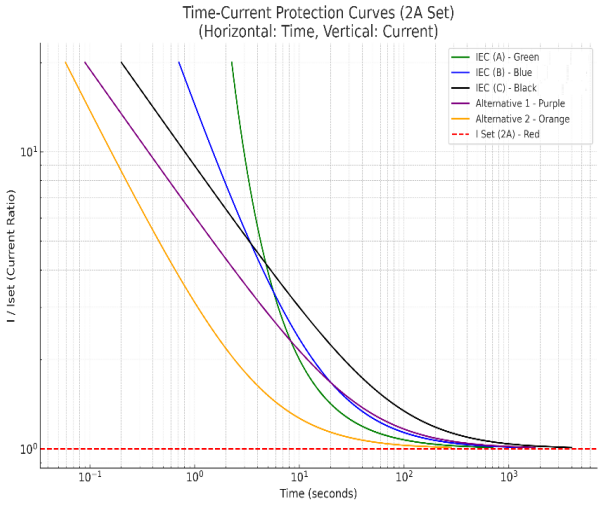
Setting the “OEX Threshold” current limit for the excitation also determines the pedestal value for the IDMT function, based on the formula given below:

$$x = T \cdot \left(\frac{k}{\left(\frac{y}{I}\right)^{a} - 1}\right)$$

(where: x = Time, y = current, T = TMS time constant, k = curve constant, a = curve constant, I = set current threshold)

IDMT will act on the “Excitation Protection” function delay time start point, **T0** as shown in the OEX function curve in the above table. This provides safety for the alternator winding and AVR excitation drive stage, based on the dynamic current drive according to continuously varying load conditions. The delay time and action at the end of the delay time is set with the OEX parameters explained in the above table.

At the end of the DELAY time, OEX protection will automatically be activated, and DAVR90 excitation drive control will be TRIPPED and AVR will shut down. If user has enabled the RELAY activation from parameter [P406], then RELAY will activate for a momentary time before the AVR is completely shut down.

Parameter Description	Parameter Limits	Explanation:
IDMT EXCITATION CURRENT SENSE MODE	**IEC A Standard Inverse** (user is not allowed to select the curve type)	

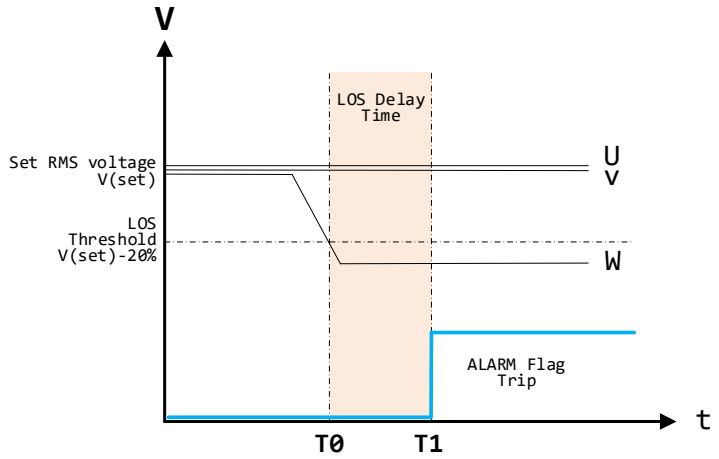
IDMT protection curve type is fixed and cannot be changed or disabled. Internal selected protection curve type is IEC A Standard Inverse characteristic and it is given in the table above.

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

If the AVR is connected in 3-phase sensing configuration, embedded software continuously controls the voltage difference between each phase voltage connected to the sense terminals U, V and W. If any of the phase voltages drops below a preset calculated value, AVR will consider this as a “Loss-of-Sense” fault and trigger an internal FAULT flag, and it will start to monitor the FAULT based on the configuration settings of the related parameters. If the “LOS Delay Time” is exceeded, the AVR will TRIP, and excitation will stop. The TRIP function is also configurable by the user according to the parameter set values.

“Loss Of Sense” voltage difference is fixed internally as -20% in comparison to the set “RMS Phase Voltage” of the alternator. Function monitors the difference of each phase voltage from the set alternator RMS phase voltage level and triggers an ALARM flag, if any of the phase voltages falls below the set -20% level. LOS TRIP is activated after the “LOS Delay” time if configured to do so.

The “LOS Alarm” can also be linked with the RELAY action if the RELAY parameter is set. Function is explained in the table below:

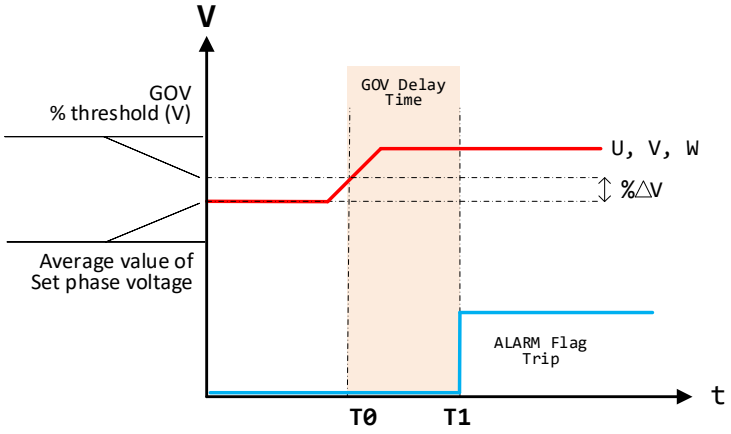
Parameter Number:	Parameter Description	Units	Parameter Limits	Graphical presentation:
[P418]	LOS DELAY parameter	Sec.	0 – 25 (Default is 5 seconds)	
[P422]	LOS RELAY activation	-	[P422] = 0	RELAY action is DISABLED
			[P422] = 1	RELAY action is ENABLED (default setting)

11.5: Generator Over Voltage (GOV) protection function:

DAVR90 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.

If the function is configured correctly, it can trigger an ALARM condition or TRIP the AVR to stop regulation. 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.
[P430]	GOV RELAY activation	-	[P430] = 0	RELAY action is DISABLED
			[P430] = 1	RELAY action is ENABLED
[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 440Vac. 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. If ALARM relay is activated and TRIP is disabled, only the relay will be energized to send an external signal and AVR will continue its normal operation.

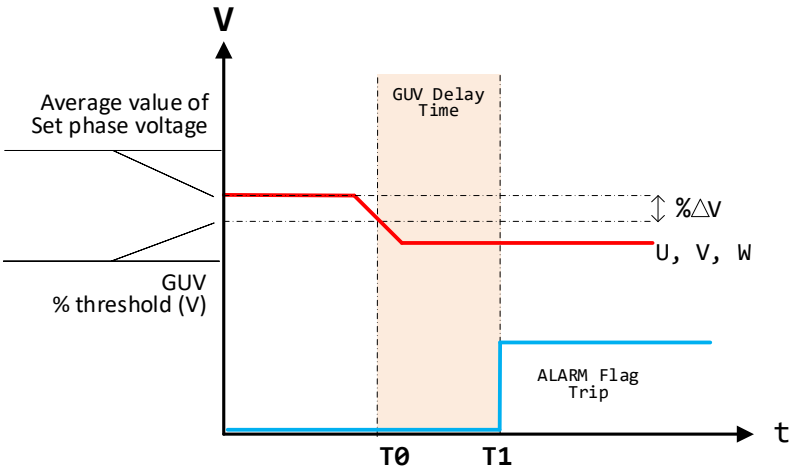
11.6: Generator Under Voltage (GUV) protection function:

DAVR90 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 RELAY or 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 360Vac 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, either a TRIP protection or a RELAY 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.
[P438]	GUV RELAY activation	-	[P438] = 0	RELAY action is DISABLED
			[P438] = 1	RELAY action is ENABLED
[P439]	GUV trip activation	-	[P439] = 0	TRIP function is DISABLED
			[P439] = 1	TRIP function is ENABLED

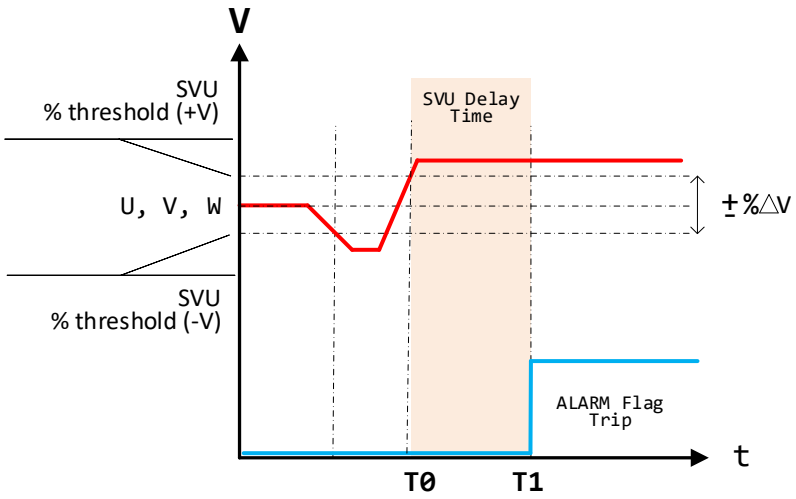
If the generator voltage rises above during “GUV Threshold” level during “GUV Delay Timer” period, the timer resets its count and will stay in reset condition until the next limit violation.

11.7: Stator Voltage Unbalance (SVU) Protection:

DAVR90 monitors the alternator STATOR voltage unbalance level and protection can be activated if configured on the AVR unit.

Stator Unbalance function monitors each phase voltage of the alternator against the “Average” value of the 3 phases. If the measured unbalance value exceeds a predetermined level, AVR sets an internal FLAG to start the protection function activation.

An internal “SVU Delay” timer starts counting to time the duration of how long the unbalance value is exceeded. If this duration exceeds the set timing limit, RELAY or TRIP action will initiate according to the function parameter configuration.

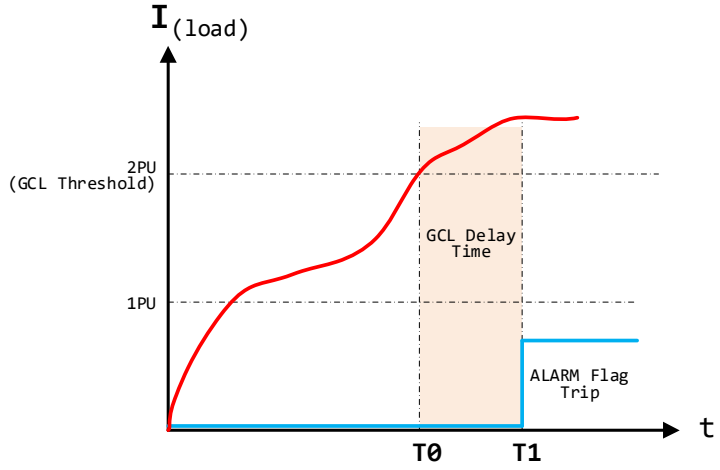
Parameter Number:	Parameter Description	Units	Parameter Limits	Graphical presentation:
[P441]	SVU percentage	%	0 – 50 (Default is 20%)	
[P442]	SVU DELAY time	Sec.	0 – 30 (default = 10 sec.)	DELAY time can be set up to 10 seconds.
[P446]	SVU RELAY activation	-	[P446] = 0	RELAY action is DISABLED
			[P446] = 1	RELAY action is ENABLED
[P447]	SVU trip activation	-	[P447] = 0	TRIP function is DISABLED
			[P447] = 1	TRIP function is ENABLED

If the measured SVU value falls below the set threshold level before the Delay timing is ended, the timer will automatically reset to zero and start counting again from the instant of violation of the SVU set threshold level. At the end of the timed duration, protection function will either trigger a RELAY action or a TRIP action, which stops the AVR excitation.

11.8: Generator Current Limit (GCL) protection Function:

It is possible to limit the alternator stator current according to application requirements. In this case, if the GCL limit is reached, it is possible to limit the load current, hence the voltage will vary according to the load current demand. The stator current is measured across CT terminals connected to the AVR.

Stator current is measured only from 'V" phase of the alternator, and it is considered that the load is balanced, and same current magnitude is flowing from "U" phase and the "W" phase of the alternator. With slightly unbalanced loads, this method may introduce slight error, but this can be ignored for GCL function execution.

Parameter Number:	Parameter Description	Units	Parameter Limits	Graphical presentation:
[P448]	GCL Threshold	%	0 – 300 (Default is 300%)	
[P450]	GCL DELAY time	Sec.	0 – 32 (default is 10 sec.)	DELAY time can be set up to 32 seconds.
[P454]	GCL RELAY activation	-	[P454] = 0	RELAY action is DISABLED
			[P454] = 1	RELAY action is ENABLED
[P455]	GCL TRIP MASKING	-	[P455] = 0	TRIP MASKING is Disabled
			[P455] = 1	TRIP function is MASKED during START-UP phase

The GCL protection function is always active in the system and cannot be terminated. This function sets a flag in the alarm log registers of the AVR each time the threshold limit is exceeded. User can only select if this function should activate an alarm relay contact or trip the AVR operation, when the limit is exceeded for the programmed time duration.

If the load current falls below "GCL Threshold" level during "GCL Delay Time" period, the timer is automatically reset and starts counting again if the limit is exceeded. In some applications, if the GCL Trip function needs to be cancelled during generator "Start Up" phase, [P455] can be set to [1] and this will enable the masking action where the GCL function will not be active during generator "Start Up" phase.

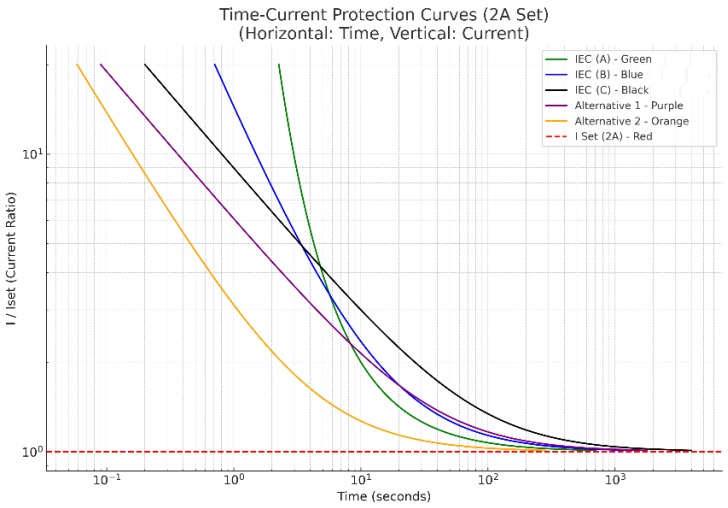
11.9: Motor Start Failure (MSF) Protection and IDMT Stator Current Sense Mode:

When starting an induction motor, it is essential that the generator can deliver enough power to the motor load, until it recovers above threshold speed, where the inrush current starts reducing. During this period, AVR needs to be able to deliver full EXCITATION power into the alternator and DAVR90 is capable of excellent performance for such cases.

If the high-current demand persists, this may cause thermal drifts in the alternator and, in such cases, the AVR can help protecting the system from damages. If configured properly, DAVR90 can trigger an alarm relay to allow for additional actions, such as to open a breaker to detach the load from the alternator (load shedding).

To calculate the thermal effect of the high load on alternator windings, DAVR90 runs a complex IDMT algorithm to detect if a thermal FLAG should be activated or not. Based on this “Thermal FLAG”, “MSF Protection” function will determine how the AVR protection function will operate. If preferred, IDMT function can also TRIP the AVR, and excitation drive will STOP.

The function details are shown in the table below:

Parameter Number:	Parameter Description	Units	Parameter Limits	Explanations:
[P476]	IDMT STATOR CURRENT SENSE MODE	-	0: Disabled 1: IEC A Standard Inverse 2: IEC B Very Inverse 3: IEC C Extreme Inverse 4: Alternative A 5: Alternative B	
[P477]	IDMT SENSE ENABLE	-	[P477] = 0	IDMT Sense DISABLED (default setting)
			[P477] = 1	IDMT Sense ENABLED
[P478]	IDMT FLAG (Read Only)	-	[P478] = 0	Excess Energy FLAG not ACTIVE
			[P478] = 1	Excess Energy FLAG ACTIVE (initiates MSF function)
[P479]	IDMT SENSE TRIP activation	-	[P479] = 0	IDMT TRIP is DISABLED
			[P479] = 1	IDMT TRIPis ENABLED (acts on Excitation drive)

User can select the IDMT protection curve characteristics with parameter [P476]. The type of curve should be selected according to the type of alternator winding and the load characteristics.

If IDMT TRIP is disabled, AVR will carry on driving the FIELD winding even though “IDMT Excess Energy FLAG” is active. Activation of this FLAG will trigger the “Motor Start Failure” function timer and DAVR90 will behave according to the configuration set as explained in the function table below:

Motor START Failure Protection Function (MSF Protection) and related parameter configurations are explained in more detail in the table below:

Parameter Number:	Parameter Description	Units	Parameter Limits	Explanations:
[P482]	MSF delay	Sec.	1 – 30 seconds	Default set to 30 seconds
[P486]	MSF RELAY activation	-	[P486] = 0	RELAY action DISABLED
			[P486] = 1	RELAY action ENABLED
[P487]	MSF TRIP activation	-	[P487] = 0	MSF TRIP function is DISABLED
			[P487] = 1	MSF TRIP function is ENABLED

11.10: ROTOR DIODE FAILURE (RDF) Protection Function:

DAVR90 monitors the Rotating Diode behaviour continuously and can detect if one or more diodes are either short circuit or open circuit during operation. In this case, related protection function is automatically activated and can be set to protect the alternator from excessive loading.

The parameter configuration is shown in the table below:

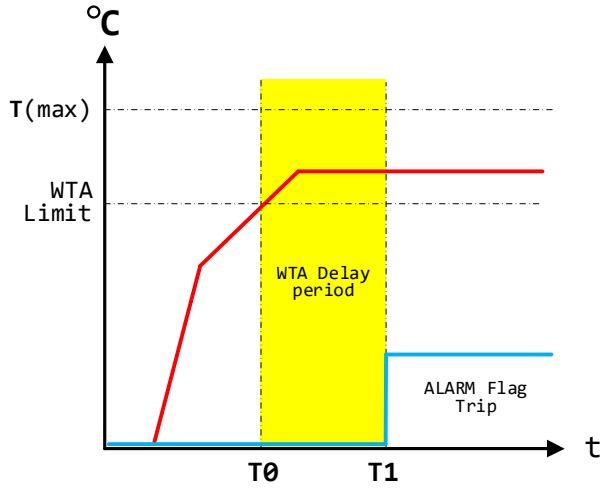
Parameter Number:	Parameter Description	Units	Parameter Limits	Explanations:
[P490]	RDF DELAY time	Sec.	0 – 32 (Default is 10 seconds)	Delay time register before alarm FLAG is activated.
[P491]	RDF function control	-	[P491] = 0	RDF protection function is DISABLED
		-	[P491] = 1	RDF protection function is ENABLED
[P494]	RDF RELAY activation	-	[P494] = 0	RDF Relay action DISABLED
			[P494] = 1	RDF Relay action is ENABLED
[P495]	RDF TRIP activation	-	[P495] = 0	RDF TRIP function is DISABLED
			[P495] = 1	RDF TRIP function is ENABLED

RDF calculations are executed internally, and user cannot set any parameters on how the failure mode is initiated. Once the failure mode is initiated, the RDF Delay timer will start counting and once this count is reached, RELAY or TRIP action can be initiated automatically.

11.11: Winding Temperature Alarm (WTA) function:

DAVR90 is equipped with 2 temperature measuring channels, where only RTD type temperature sensors can be used. It is preferred to use Pt100 type temperature sensors for the windings with the proper type selected for any particular application, considering the potential insulation barrier for the sensor connection.

With the correct sensor connected to the AUX terminals (T1, T2) and (T3, T4) on the AVR unit, user is expected to configure the

Parameter Number:	Parameter Description	Units	Parameter Limits	Graphical presentation:
[P456]	WTA Threshold	°C	40 – 200 (Default is 200%)	
[P458]	WTA DELAY time	Sec.	0 – 15 (default = 10 sec.)	DELAY time can be set up to 15 seconds.
[P459]	WTA activation ENABLE	-	[P459] = 0	WTA action is DISABLED
			[P459] = 1	WTA action is ENABLED

In DAVR90, measuring the winding temperature has flexible parameters so that the user can protect the winding under very safe limits and at the same time allow momentary high-temperature peaks without jeopardising the alternator safety.

Therefore, “Winding Temperature Alarm” and “Winding Temperature Limit” actions are organised as two independent protection functions and can be configured according to application requirements. In both protection functions, there is ALARM and TRIP features, and user can select which action will be effective in case of exceeding the set limits.

WTA temperature limit is 200°C maximum and can be set with an accuracy of ±1°C. There is no built-in hysteresis as the timer is designed to RESET as soon as the temperature falls below the threshold limit value.

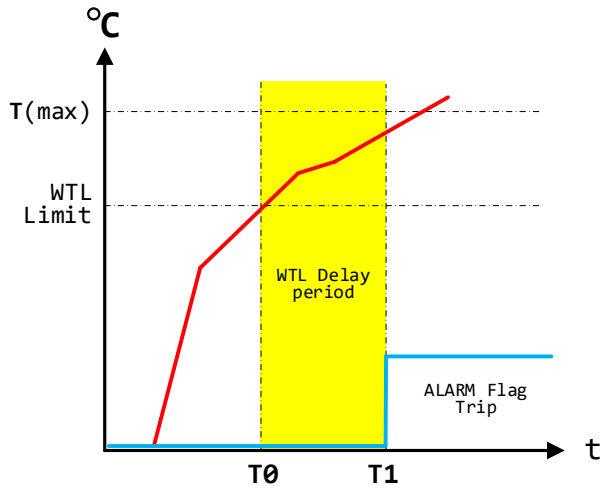
WTA function can be ENABLED or DISABLED according to application requirements. If not going to be used, it is recommended that the function is DISABLED from the parameter menu.

11.12: Winding Temperature Limit (WTL) protection function:

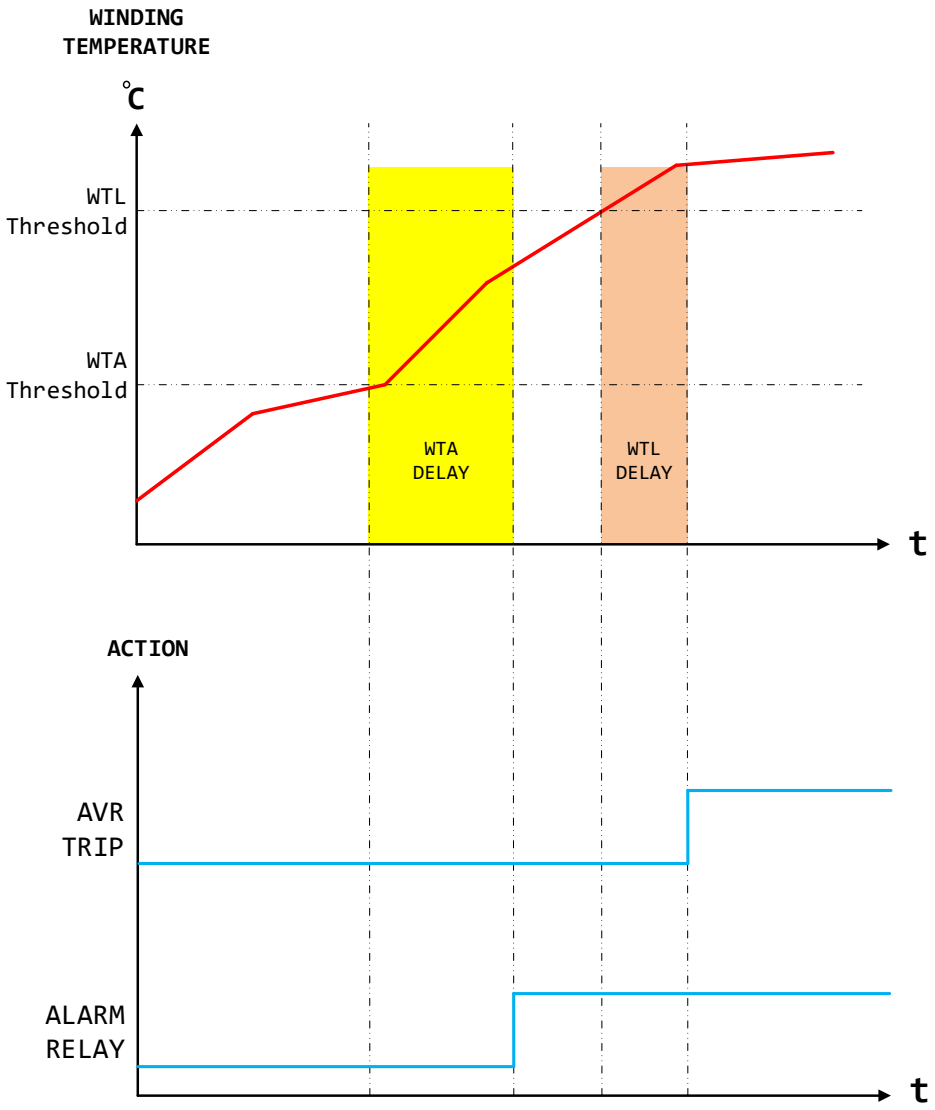
DAVR90 has an additional secondary temperature protection function, named as “Winding Temperature Limit” protection function (WTL). This function acts as a secondary temperature protection feature, which has a higher temperature setting limit. In some applications, user can set WTA protection function to generate an ALARM RELAY contact to take necessary precautions (like load shedding) and if the temperature rise persists, WTL function can act as a TRIP protection for the AVR to shut off the excitation drive completely.

In some applications, this feature gives the user a “Fail-Safe” protection of the FIELD winding and/or the winding where the temperature sensor is located. In some applications more than one winding temperature can be measured with similar characteristics on each measuring channel.

The function details are shown in the table below:

Parameter Number:	Parameter Description	Units	Parameter Limits	Graphical presentation:
[P464]	WTL Threshold	°C	40 – 300 (Default is 250%)	
[P466]	WTL DELAY time	Sec.	0 – 15 (default = 10 sec.)	DELAY time can be set up to 15 seconds.
[P467]	WTL activation ENABLE	-	[P467] = 0	WTL action is DISABLED
			[P467] = 1	WTL action is ENABLED

An example of the AVR behaviour with cascaded temperature protection setup is shown in the graphical representation below:



NOTE: This "**Cascade Protection**" application can only be applied if the AVR is fed from PMG power unit. This application is not valid for SHUNT and/or AUXILIARY power connections.

11.13: Relay Operation Mode Setting:

The relay can be programmed to be N/C or N/O based on the application requirement. The parameter and its functional details are explained in the table below:

Parameter Number:	Parameter Description	Setting limits	Explanations:
[P150]	RELAY Normal Position	0	Normally OPEN contact setting (contact closes if relay is tripped)
		1	Normally CLOSED contact setting (contact opens if relay is tripped)

Each ALARM state can be monitored internal to the AVR unit. If required, the RELAY can be linked to any of the alarm conditions explained in the table below. User can set a defined “trigger threshold level” and a “delay time” before the relay is activated.

11.14: Alarm FLAGS and Alarm output RESET:

If an ALARM condition occurs on DAVR90, 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 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, by 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

11.15: Alarm LED Indication:

DAVR90 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.

12- Communication ports:

DAVR90 is equipped with a USB type-B com port for device configuration and also performance monitoring during system commissioning.

USB port is galvanically isolated from the power connection terminals group of the AVR unit. Therefore, the com port on DAVR90 can be used safely while the generator is running,

All AUXILIARY terminals and the USB COM port are galvanically connected to the same isolated power supply; therefore, it must be observed that, COM ports and the AUXILIARY terminals are all floating on the same potential, isolated from the alternator power side.

USB port is designed for device configuration and at the same time, PC-Tools software package can run during AVR commissioning to monitor the alternator behaviour on the PC screen, using oscilloscope tools of the configuration software package.

12.1: Connection to USB port:

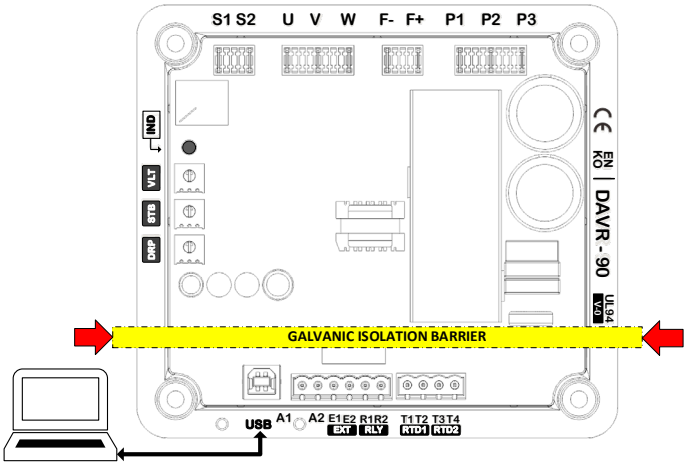
To configure the AVR, it is required to connect to the USB port and use PC-Tool Software package to reach all the configurable parameters in the AVR unit.

Use a printer cable (type-B) to connect to the AVR unit. Make sure to use a new cable for reliable operation. The unit receives its own power to feed its microcontroller circuit inside the AVR, therefore, when connected via USB port, no external power is required for the AVR configuration.

Once connected and secured, it is possible to read all the current parameter data from the AVR and at the same time, carry out all necessary parameter settings and saving them back in the AVR memory. It is also possible to check all the alarm logs and operating hours information and also, reset all alarm flags and clear internal error registers.

Parameter list is given at the end of this user manual. The parameter numbers do not follow in suit because the intermediate parameter numbers are hidden, and they are not available to the user. These parameters can only be set during manufacturing, and user cannot reach these parameters during configuration.

USB connection data is set in the PC-Tools software menu and passwords are controlled by this SW.

COMPORTS	COMPORT connections
USB PORT CONNECTION (TYPE-B CABLE) (no external power is required)	

12.2: Firmware ID registers:

DAVR90 has two additional registers where the device SW ID is stored. If FIRMWARE update is required from remote access point, it is required to know the “Internal Bootloader Version” number and at the same time, the remote-control software needs to read the existing Firmware version number. These data are stored in parameter addresses as shown in the table below:

Parameter Number:	Parameter Description	Setting limits	Explanations:
[P9975]	Current BOOTLOADER version number	1000 – 32767 (Default setting = 1000)	Required if the FIRMWARE of the AVR is to be upgraded from a remote access point. These registers are “Read-Only” registers and cannot be changed.
[P9976]	Current FIRMWARE version number	1000 -32767 (Default setting = 1000)	

13- RESET Parameters back to FACTORY settings:

13.1: RESET back to FACTORY settings:

DAVR90 comes with a complete set of parameters, set for most common use applications. User can change these parameters according to their specific application requirements. If user wants to reset all parameter values back to the FACTORY Default settings, this can be achieved by setting appropriate parameter values from the menu.

Factory Default setting procedure is explained on more detail in the below table:

Parameter Number:	Parameter Description	Setting limits	Explanations:
[P203]	FACTORY DEFAULT parameter RESET function	[P203] = 0 (Parameters differ from factory values. Read only)	In order to reset all parameter values back to "Factory Default Settings" set P203 to "1"
		[P203] = 1 (RESET all parameters to FACTORY settings)	

DAVR90 keeps a time log internally to control the total number of hours of operation. This timer is NOT a REAL TIME timer but an internal timer, which start to increment as the AVR power inputs are energized. The timer is accumulative and stored permanently in the non-volatile memory of the microcontroller circuit.

13.2: RESET internal TIME clock:

It is possible to check the total hours that the AVR has been in operation. If required, the timer can be RESET by setting the appropriate parameter value in the parameter menu. The function is explained in more detail below:

Parameter Number:	Parameter Description	Setting limits	Explanations:
[P204]	RESET Internal TIME clock	[P204] = 0 (Internal clock is accumulating. Read only)	To reset internal TIME clock, set [P203] to "1"
		[P204] = 1 (RESET internal TIME clock to initial state.)	

NOTE: The internal TIME clock is NOT a "Real-Time" clock. It is an accumulative TIME clock for service management only. Clock only is incremented while the AVR is energized.

14- Parameter List for DAVR90:

PARAMETER TYPE	PARAMETER NUMBER	NAME	UNIT	Min. Value	Max. Value	Factory default	Value/Mask	Comments/Explanations
MONITORING PARAMATERS (Read only)	P000	UV RMS Voltage	V	0	600	0	-	Phase – Phase RMS Voltage measurement
	P001	VW RMS Voltage	V	0	600	0	-	Phase – Phase RMS Voltage measurement
	P002	WU RMS Voltage	V	0	600	0	-	Phase – Phase RMS Voltage measurement
	P006	UV Frequency	Hz	0	80	0	-	Phase – Phase Frequency measurement
	P007	VW Frequency	Hz	0	80	0	-	Phase – Phase Frequency measurement
	P008	WU Frequency	Hz	0	80	0	-	Phase – Phase Frequency measurement
	P014	Field Current RMS	A	0	10	0	-	Field Current RMS measurement
	P020	DROOP Current RMS	%PU	0	100	0	-	DROOP Current RMS measurement by 1 PU
	P025	AUX Voltage Input Value	V	0	10	0	-	Auxiliary voltage input measurement
	P026	AUX Current Input Value	mA	0	20	0	-	Auxiliary current input measurement
	P027	VOLTS Pot	%	0	30	0	-	VOLTS Trimmer measurement. Percentage of the effect on the output voltage
	P028	STAB Pot	%	0	30	0	-	STAB Trimmer measurement. Percentage of the effect on the PID parameters
	P029	DROOP Pot	%	0	30	0	-	DROOP Trimmer measurement. Percentage of the effect on the output voltage
	P033	EXT Pot	%	0	30	0	-	External pot measurement
	P034	EXT Pot Connected	-	0	1	0	0: N/A 1: Connected	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.
	P035	Controller State	-	0	6	0	0: Pre Init 1: Init 2: Startup 3: Standby 4: Soft Start Delay 5: Soft Start 6: Normal Operation	AVR's current status
	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
	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
	P050	SHORT CIRCUIT	-	0	1	0	-	Stator Current Measurement reached short circuit
	P051	RELAY	-	0	1	0	-	Alarm Relay Activated
	P052	OUT TRIP	-	0	1	0	-	AVR Output Cutoff
	P054	SCM	-	0	1	0	-	Stator Current IDMT Activated
	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

PARAMETER TYPE	PARAMETER NUMBER	NAME	UNIT	Min. Value	Max. Value	Factory default	Value/Mask	Comments/Explanations
MONITORING PARAMATERS (Read only)	P059	GUV	-	0	1	0	-	Generator Under Voltage Protection Activated
	P060	SVU	-	0	1	0	-	Stator Voltage Unbalance Protection Activated
	P061	GCL	-	0	1	0	-	Generator Current Limit Protection Activated
	P062	MSF	-	0	1	0	-	Motor Start Failed
	P063	RDF	-	0	1	0	-	Rotating Diode Failed
	P064	WTA	-	0	1	0	-	Winding Temperature Alarm Protection Activated
	P065	WTL	-	0	1	0	-	Winding Temperature Limit Protection Activated
	P093	Maximum ambient temperature history	°C	0	85	0	-	Maximum ambient temperature recorded for the AVR.
	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

PARAMETER TYPE	PARAMETER NUMBER	NAME	UNIT	Min. Value	Max. Value	Factory default	Value/Mask	Comments/Explanations
CONFIGURAION PARAMETERS (read / write)	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	0: Stop 1: Start	AVR's start status flag. Also can be used to manually start AVR if there is no error.
	P102	AVR Auto-start		0	1	0	0: Disabled 1: Enabled	AVR auto start setting. If enabled AVR will start as soon as there is no errors.
	P103	Clear Output Errors		0	1	0	0: Disabled 1: Enabled	Clear error flags setting. Note: flags will automatically turn on if error continues.
	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	0.01	100	0.5		Reference Voltage limit for not causing unstable reference while using pots etc.
	P109	Minimum Reference Percentage	%	0	0	100		Sets Minimum Reference setpoint limit percentage according to Reference RMS.
	P110	PID Kp		0	0	2048		Proportional coefficient of the controller. Increasing it will cause faster AVR reaction but worse steady state stability.
	P111	PID Ki		0	0	2048		Integral coefficient of the controller. Increasing it will cause better steady state stability but worse reaction time.
	P112	PID Kd		0	0	2048		Derivative coefficient of the controller. Increasing it will cause faster AVR reaction but worse steady state stability.
	P117	UFRO Knee Point	Hz	0	40	65		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	0	80		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	0	480		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	0: NORMAL 1: ENHANCED	Selection of the recover after derating mode. Should be changed according to block load performance of the system.

CONFIGURAION PARAMETERS (read / write)	P121	Short Circuit Threshold	mA	1000	15000	4200		Short Circuit Mode Threshold. AVR will get into the short circuit supply mode after this threshold. Attention! This Mode will disable LOS GCL and GUV. Disables after Droop Current drops below threshold.
	P122	Sensing Mode		0	7	4	4: W – U 7: U – V – W	0: N/A 1: U-V 2: V-W 4: W-U 7: U-V-W
	P123	AUX Input Mode		0	3	0	0: Disabled 1: - 5 / + 5V 2: 4mA – 20mA 3: 0V – 10V	Auxiliary input mode selection. AUX input will affect output voltage. In case of external pot connection this input should be disabled.
	P124	AUX Input Range	%	0	100	38		Auxiliary input's effect range on output voltage
	P134	Power Transfer Ratio		1	80	1		1 PU Generator Nominal Output Power. Used for J1939 Standard.
	P135	Current Transfer Ratio (monitor only)	A	0	32767	1	205: X / 5 1024: X / 1	Current transfer ratio. This ratio determines 1PU SENSE current value.
	P137	DROOP Mode		0	3	0	0: Disabled 1: Line DROOP 2: Load Balance 3: Quadrature	DROOP function determines stator current's effect on output reference voltage.
	P138	DROOP Phase Compensation	°	-60	60	0		DROOP current phase compensation. Needed if there is phase shift between current and 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.
	P141	DROOP Trimmer Effective Range	%	0	10	6		DROOP trimmer effective range on output voltage.
	P142	External Pot Effective Range	%	0	30	30		External pot effective range on output voltage.
	P150	Relay Normal Position		0	1	0	0: Normally Open 1: Normally Closed	Determines relay status while there are no errors
	P203	Reset Parameters To Defaults		0	1	0	0: - 1: Reset	Reset all parameters to their defaults.
	P204	Reset Engine Hours		0	1	0	0: - 1: Reset	
	P270	ADT "A" Input Mode		0	5	0	0: Disabled 1: Analog 2: Digital 3: Winding Temp 4: Aux Temp 5: External Start 6: External Stop	ADT A input type selection. This parameter also effects related protections to selected type.
	P271	ADT "A" Temperature	°C	0	255	0		Temperature value of the ADT A input.
	P272	ADT "A" Value		0	255	0		This value could be Analog Digital Temperature according to input type selection.
	P277	ADT B Input Mode		0	5	0	0: Disabled 1: Analog 2: Digital 3: Winding Temp 4: Aux Temp 5: External Start 6: External Stop	ADT B input type selection. This parameter also effects related protections to selected type.
	P278	ADT B Temperature	°C	0	255	0		Temperature value of the ADT input.

CONFIGURAION PARAMETERS (read / write)	P279	ADT B Value		0	255	0		This value could be Analog Digital Temperature according to input type selection.
	P400	OEX Threshold	A	0	15	5		Over Excitation Trigger Threshold
	P402	OEX Delay	S	0	10	10		Over Excitation Delay Time
	P406	OEX Relay		0	1	1	0: Disabled 1: Enabled	Over Excitation Error Relay Trigger Flag
	P418	LOS Delay	S	0	25	5		Loss Of Sense Delay Time
	P422	LOS Relay		0	1	1	0: Disabled 1: Enabled	Loss Of Sense Error Relay Trigger Flag
	P425	GOV Percentage	%	0	50	20		Generator Over Voltage Trigger Level
	P426	GOV Delay	S	0	10	10		Generator Over Voltage Delay Time
	P430	GOV Relay		0	1	1	0: Disabled 1: Enabled	Generator Over Voltage Relay Trigger Flag
	P431	GOV Trip		0	1	1	0: Disabled 1: Enabled	Generator Over Voltage Output Trip Flag
	P433	GUV Percentage	%	0	50	0		Generator Under Voltage Trigger Level
	P434	GUV Delay	S	0	10	10		Generator Under Voltage Delay Time
	P438	GUV Relay		0	1	1	0: Disabled 1: Enabled	Generator Under Voltage Relay Trigger Flag
	P439	GUV Trip		0	1	0	0: Disabled 1: Enabled	Generator Under Voltage Output Trip Flag
	P441	SVU Percentage	%	0	50	20		Stator Voltage Unbalance Trigger Level
	P442	SVU Delay	S	0	30	10		Stator Voltage Unbalance Delay Time
	P446	SVU Relay		0	1	1	0: Disabled 1: Enabled	Stator Voltage Unbalance Relay Trigger Flag
	P447	SVU Trip		0	1	1	0: Disabled 1: Enabled	Stator Voltage Unbalance Output Trip Flag
	P448	GCL Threshold	%	0	300	300		Generator Current Limit Trigger Level
	P450	GCL Delay		0	32	10		Generator Current Limit Delay Time
	P454	GCL Relay		0	1	1	0: Disabled 1: Enabled	
	P455	GCL Trip		0	1	1	0: Disabled 1: Enabled	Generator Current Limit Masking on Startup Flag
	P456	WTA Threshold	°C	40	200	200		Winding Temperature Alarm Trigger Level
	P458	WTA Delay	S	0	15	10		Winding Temperature Alarm Delay Time
	P459	WTA Enable		0	1	0	0: Disabled 1: Enabled	Winding Temperature Alarm Enable Flag
	P464	WTL Threshold	°C	40	300	250		Winding Temperature Limit Trigger Level
	P466	WTL Delay	S	0	15	10		Winding Temperature Limit Delay Time
	P467	WTL Enable		0	1	0	0: Disabled 1: Enabled	Winding Temperature Limit Enable Flag
	P476	IDMT Sense Mode		0	2	2	0: Disabled 1: IEC A Standard 2: IEC B Very 3: IEC C Extreme 4: Alternative A 5: Alternative B	IDMT Fuse Curve mode selection.
	P477	IDMT Sense Enable		0	1	0	0: Disabled 1: Enabled	IDMT Fuse Enable
	P479	IDMT Sense Trip		0	1	0	0: Disabled 1: Enabled	IDMT Fuse Tripped flag.
	P482	MSF Delay	S	1	30	30		Motor Start Failure Delay Time
	P486	MSF Relay		0	1	1	0: Disabled 1: Enabled	Motor Start Failure Alarm Relay Trigger Flag

	P487	MSF Trip		0	1	1	0: Disabled 1: Enabled	Motor Start Failure Output Trip Flag
	P490	RDF Delay	S	1	32	10		Rotating Diode Failure Delay Time
	P491	RDF Enable/Disable		0	1	0	0: Disabled 1: Enabled	RDF Function control setting
	P494	RDF Relay		0	1	1	0: Disabled 1: Enabled	Rotating Diode Failure Relay Trigger Flag
	P495	RDF Trip		0	1	1	0: Disabled 1: Enabled	Rotating Diode Failure Output Trip Flag
	P9975	Device BL Version		1000	32767	1000		Current bootloader version of the AVR.
	P9976	Device SW Version		1000	32767	1000		Current software version of the AVR.

15- 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 parameter configuration may be set incorrectly. In this case, following steps can be applied to fix some of the major possible problems with the system.

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

Troubleshooting: No Voltage Generation on Alternator Stator Terminals

If the AVR is connected to an alternator and fails to generate voltage at the stator terminals during start-up, follow these steps to diagnose and resolve the issue:

1. **Verify AVR Installation:** Ensure the AVR is properly installed and wired according to the instructions in this manual. Confirm that all connections are secure and that wires are correctly routed.
2. **Check Field Winding and Wiring:** Using a multimeter, verify that the alternator's field winding is intact and displays the correct impedance (Ω) as specified by the manufacturer. Also, confirm that the field wiring polarity is correctly matched on the AVR.
3. **Measure Residual Voltage:** if connected in SHUNT or AUX configuration, disconnect the P1 and P2 terminals from the AVR, run the generator, and check the residual voltage across these wires. It should be at least 6Vac RMS. If this voltage is absent, flash the field using a 9V DC battery to restore residual voltage above 6Vac RMS, then reconnect the terminals and restart the generator.
4. **Inspect Rotor Diodes:** Ensure that all rotor diodes are functioning correctly and are not faulty.
5. **Review Configuration Parameters:** Confirm that the AVR start control parameters are correctly set and that no conflicts exist in the start-up sequence.
6. **Examine Wiring Harness:** Check for any faults, loose connections, or damage in the wiring harness leading to and from the AVR unit.

By following these steps, you can systematically troubleshoot and resolve issues preventing voltage generation.

15.2 Voltage is generated but voltage reading is not correct:

Troubleshooting: Incorrect Voltage Reading Under Normal Running Conditions

If the alternator is not generating the correct voltage under normal operating conditions, follow these steps to identify and resolve the issue:

1. **Verify Voltage Range Selection:** Ensure that the "voltage range selection" is correctly set according to the wiring configuration.
2. **Check the VLT Pot Setting:** Confirm that the required voltage value can be properly set when the VLT pot is positioned near the middle.
3. **Ensure Correct Engine Speed & UFRO Knee Parameter:** Check that the engine is running at the correct speed and that the UFRO Knee parameter is properly set.
4. **Inspect Excitor Winding & Field Current:** When the generator is running under no-load conditions, verify that the field current is close to the calculated value. Also, check for any faulty wiring connections.
5. **Examine Rotor Diodes:** Ensure that all rotor diodes are in good working condition and functioning properly.

15.3 Voltage stability issues:

Troubleshooting: Stability Issues During Operation

If the generator experiences stability problems, follow these steps to diagnose and resolve the issue:

1. **Verify Engine Speed:** Run the generator under no-load conditions and ensure that the engine maintains a stable speed without fluctuations. If speed variations occur, check the engine governor settings to stabilize the speed.
2. **Adjust PID parameters:** Set STB pot at its middle position. Connect PC-Tools SW via USB port and set the PID parameters to give the best performance for your application. If available, use “AUTOTUNE” function and let the system select optimum PID parameters to match your alternator frame type.
3. **Inspect Excitor Winding and Wiring:** Verify proper Excitor winding installation and ensure AVR terminals are wired correctly. Also, check that voltage sensing parameters are properly configured.
4. **Examine Rotor Diodes:** Ensure that all rotor diodes are functioning correctly and are not faulty.
5. **Confirm Stable Operation Under Load:** Once voltage stability is achieved, verify that the generator operates as expected under load conditions. Additionally, check the dynamic response during load-on and load-off transitions to ensure performance remains within specified limits.
6. **Check Field Winding Power Supply:** If the issue persists, evaluate the field winding power requirements and review how the AVR unit is wired via P1, P2 and P3 terminals. Check power connections and check harness, make sure that power source is connected properly and correctly.