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Application Guidance Notes: Technical Information from STAMFORD | AvK

AGN 023 – AVR Features

ALTERNATOR DE-EXCITATION WITH K1 AND K2 ON ANALOGUE AVRs

On STAMFORD alternators, analogue AVR's, MX321, MX341 and MX342 have a pair of terminals marked K1 – K2. These terminals are a link in the rectified PMG output power supply to the AVR, which becomes the available controlled DC voltage to be applied across the Exciter Field at the F1 – F2 output of AVR. In normal operating conditions these terminals must be linked in order for the AVR's output power device – thyristor – to be linked to the AVR's internal output power supply rail.

It therefore figures, that if the link between K1 and K2 terminals is removed – open circuited – there will be no output from the AVR into the Exciter Field and consequently, the alternator will stop generating an output voltage. This option to open circuit K1 and K2 can therefore, be used to stop the alternator from generating an output voltage under any required operating situation. This may be as part of the planned maintenance safe working procedure, or as part of a system protection between alternator terminals and the Generating Set Circuit Breaker.

Method

Any switching contact put into the K1 and K2 circuit should be rated at **240V ac, at 10A**. Considering a safety overcurrent protection system, based on opening K1 - K2, must be based on a full understanding of the associated risks. This scheme should be considered as a secondary protection and not a primary protection system.

The connections between the alternator output terminals and the Generating Set's output Circuit Breaker must be as short as possible and because this length of conductor is not protected by the Generating Set Circuit Breaker, then design of this short length of conductor

system must be very carefully considered. It must be fitted within a designed structural system to ensure that it cannot be mechanically damaged, and must be very carefully chosen not to be damaged by the vibration of the Engine/alternator assembly. Electrically, it must be capable of handling the full fault current between the alternator output terminals and the Generating Set Circuit Breaker, as this is the first point at which overcurrent protection is fitted in the Generating Set's electrical power system.

A good and satisfactory design could be said to be one that incorporates all the mechanical protection as outlined above for the conductor run between alternator terminals and Generating Set Circuit Breaker and this be considered as the primary protection system. The conductors have been so well designed that the chances of a problem causing them to fail is almost never going to happen. But if, in the very unlikely event a failure does occur, then the next line of protection is an overcurrent detecting system for this short conductor run which will cause K1 - K2 to be open circuited. Then the final protection system is the standard feature on all MX type AVR's, which automatically shut down after some 8 seconds under their 'Over excitation' protection system.

B0 - B1 is part of the MX321 AVR's over-voltage protection system. If an over voltage condition occurs for more than say 2 seconds, then the AVR will give a Voltage pulse at terminals B0-B1. This Voltage pulse has been designed to work in conjunction with the 'Optional Extra' Excitation Circuit Breaker available to be fitted across K1 - K2. This Circuit Breaker has a 'Shunt Trip' coil fitted. When 'Alternator output over volts' is detected and this AVR safety circuit is activated, the AVR gives a voltage pulse at terminals B0 - B1. This 'Voltage pulse' activates the shunt trip mechanism in the Excitation-CB then K1 - K2 is automatically opened and so the alternator output decays to zero. Under fault condition the decay could be within 0.1 second and under no load conditions it would take some 0.5 second. Considering using this B0 - B1 voltage to operate a circuit other than for the STAMFORD designed system can damage the AVR. The STAMFORD Excitation CB has a coil resistance of some 35ohms, needs 0.15A to operate the shunt trip, and by instantly opening K1 - K2, the duration of the B0 - B1 output is controlled to be no more than 60milliseconds. Exceeding any of these values damages AVR components and requires the AVR to be replaced.

To still ensure compliance with EMC Legislation, the leads connected to K1 and K2 should be screened and ideally, go no further than a Generating Set Frame mounted Relay located and installed in a manner to ensure vibration will not cause a relay reliability problem.

If the reason for the inclusion of this circuitry is to provide over load protection and is therefore being driven by appropriate over current detecting monitor, then the reliability of this circuit and its electro-mechanical component parts is absolutely paramount.

The use of such a protection method/system would have to be considered in conjunction with appropriate local regulations, eg; IEE Regulations for UK, Classifying Society Regulations for Marine, etc.

Some abiding Regulations and Legislation may well consider this to be an ideal back-up protection system, but not a proven method for principal, front line protection scheme. We believe it may well be a case of identifying the 'Risk' for the particular Application and then

deciding upon its suitability. Note: *We could not stand up in a Court of Law and argue it any differently. In these days of Liability prosecution and large compensation pay-outs, we must be very accurate about its protection capabilities].*

LOAD ACCEPTANCE AND AVR UNDER FREQUENCY ROLL OFF (UFRO)

If an alternator is run at below rated speed, the only way to maintain rated voltage is to increase the excitation current. However, reduced running speed means reduced fan speed and, in turn, reduced cooling air through the alternator. It therefore becomes imperative to reduce the excitation current, to ensure the rotor does not become over heated. This, in turn, further reduces the output voltage.

All STAMFORD and AvK Digital and analogue AVR's have a built in capability to recognise under-speed running and when this occurs the AVR will automatically reduce the alternator's excitation level and so output voltage. This feature is known as Under Frequency Roll Off or simply UFRO.

Typical electrical equipment as normally powered by an alternator, has been designed to operate at a fixed voltage and fixed frequency. Most of this equipment has a tolerance to a +/- % variation for V and Hz around the nominal, but will be even more tolerant if the V and Hz stay in proportion as they are reduced [or even increased]. So the UFRO circuit not only offers protection for the alternator rotor winding; it is also offering some sympathetic protection for any connected load.

There is an even greater indirect benefit of the UFRO and this is often referred to as 'Engine Load Relief'. If the alternator driven speed is reduced during an applied load step to the Generating Set, therefore a transient condition, which results in a short term condition where the engine cannot maintain speed, then if the AVR detects under-speed running, it will automatically reduce the alternator excitation level, therefore output voltage, and this in turn will reduce the level of output current.

UFRO Settings

Required UFRO settings may be programmed into the functionality of Digital AVRs. All analogue AVRs have an adjustment 'pot' to enable the speed [Hz] to be set at which the UFRO circuit becomes activated. This is referred to as UFRO knee-point and when this occurs the AVR mounted LED will light. The factory setting for UFRO knee-point is at 47.5Hz for 50Hz operation and 57.5Hz for 60Hz operation. This means when the speed drops below the knee point, the output voltage will start reducing.

The rate at which the voltage is reduced compared to the reduced speed can be adjusted by the adjusting the DIP 'pot'. This adjustability is available on all MX type AVRs.

The rate at which the voltage is allowed to rise as the speed returns to nominal can be adjusted by adjusting the DIP 'pot'. This adjustability is available on all MX type AVRs.

General Notes on AVR Adjustments on Analogue AVRs

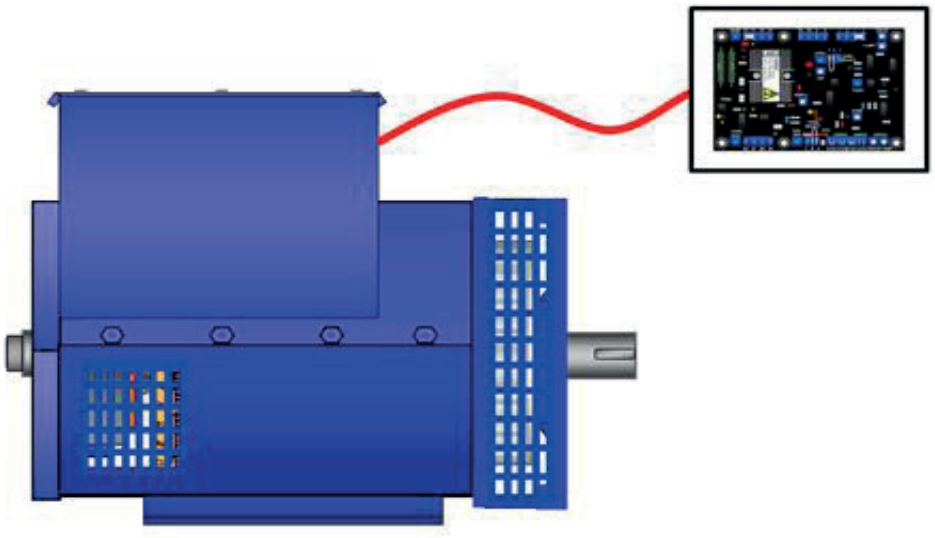
Achieving the lowest possible Transient Voltage Dip percentage [TVD%] on a Generating Set after a block load has been applied, will result from optimum setting of the AVR control system. The STABILITY 'pot' will ensure that the AVR's dynamic response to a sudden load-step change is recognised and acted upon is the fastest possible time. It is possible to set the STAB 'pot' to make the AVR respond too fast, and this causes the output voltage to be unstable under steady state load conditions.

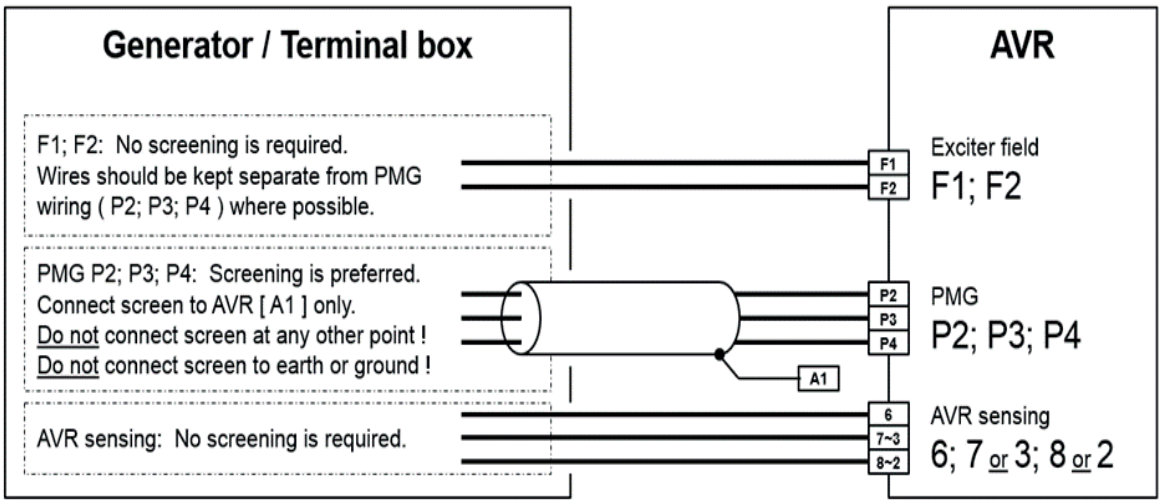
The AVR's UFRO circuit will recognise that the engine is in trouble, because the speed [Hz] has reduced, optimising the point at which the UFRO circuit becomes active, achieved by where the UFRO 'pot' is set, and then the setting characteristics of the DIP and DWELL to achieve a reduced level of output voltage, that helps the engine stay as close as possible to the nominal operating speed.

It must be remembered that the engine speed governor may also have adjustable options that will assist under block load conditions. Any exercise to optimise the block load acceptance performance of a Generating Set will involve independent adjustment of the AVR and then engine speed control. Before this exercise is complete it may well require a subtle readjust of either governor or AVR to ensure compatibility between these two independent control systems.

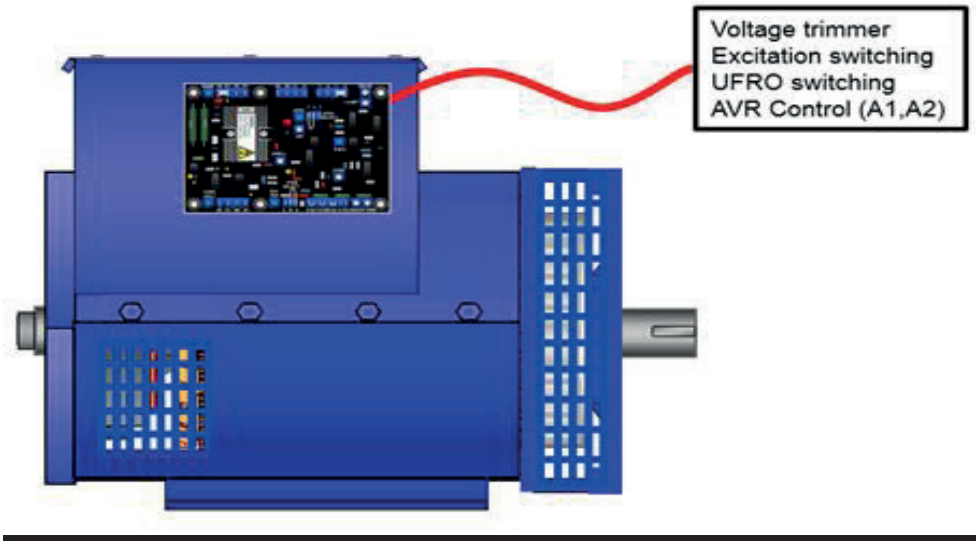
REMOTE AVR CONNECTIONS

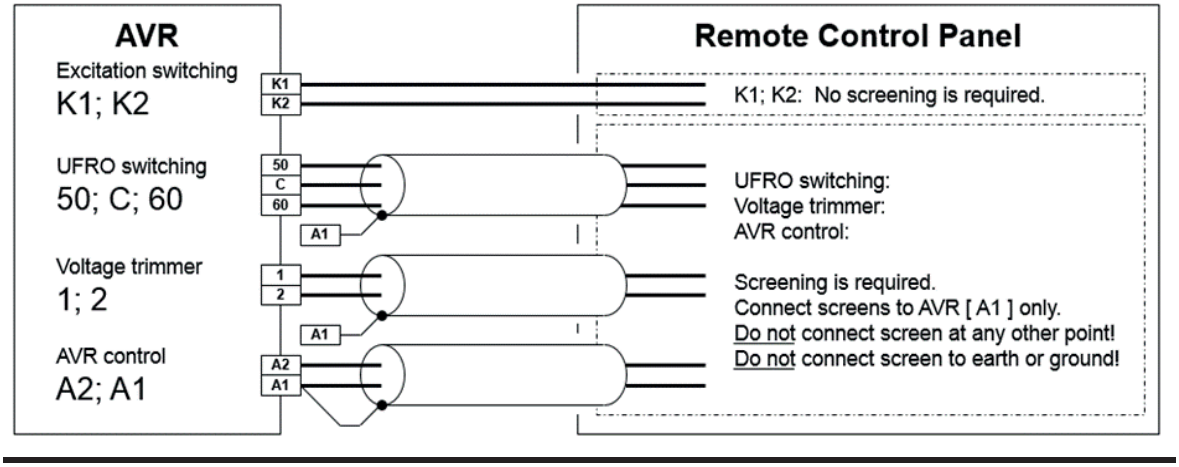
The information in this section is useful for applications when an AVR is mounted external to the alternator. Connection details of remote AVR devices are provided and for power requirements, please refer to the AVR datasheets available from the Stamford | AvK website: www.stamford-avk.com





External AVR Connections





Remote Trim Pot Sensitivity

The standard recommended value of variable resistance for “remote trimming” of AVR type MX321 is 4K7ohms and this will give an adjustment of range for the alternator’s nominal output voltage of 12%. The idea being to set the Remote ‘pot’ at its mid-point, the alternator’s output voltage at nominal level by use of the AVR mounted ‘pot’, and then the Remote ‘pot’ will provide adjustment of some +/- 6% about the nominal.

As the standard ‘pot’ rotational movement is some 270 degrees, and this equates to 12% of the alternator’s output voltage variation, it figures that when a linear ‘pot’ is used, the alternator’s output voltage will be varied by 1% for every 22.5 degrees of ‘pot’ adjustment. For a nominal 415V alternator, +/- 6% = 415 + 25 / - 25 V = 390V to 440V. This means that a 1V change for every 5.4 degrees of ‘pot’ rotation.

Note. If the witnessed situation meant that the Remote ‘pot’ changed the alternator’s output voltage by some 5V as a minimum movement, then this suggests that the ‘pot’ was being rotated by some 27 degrees, or 10% of its total movement. This suggests that the ‘pot’ motor was being operated by a system that caused it to ‘run on’ and rotate more than expected, this can be a problem when ‘Inch’ buttons are used for motor control, or the motor- to-pot gearing is too coarse. So the original situation being considered that the ‘front-end’ of the AVR was too sensitive cannot be supported. The value of the ‘pot’ and the sensitivity of the AVR could be confirmed by taking the ‘pot’ from 0 degrees to 270 degrees and noting the output voltage variation.

MX321 requires a 4k7 ohms pot and MX341 requires 1k0 ohms pot.

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