

December 13, 2004

**Subject: Application Note #27  
Beckwith Electric M-3425A Generator Protection Relay  
Setting Clarification "27TN" Third Harmonic Undervoltage Element**

**Applicable Products: M-3425A Generator Protection Relay only**

**Summary:**

We are issuing an important setting clarification for the M-3425A Generator Protection relay. This clarification is applicable to all M-3425A products. No other Beckwith Electric products, including the M-3425, are affected by this instruction.

When blocking the third harmonic undervoltage element (27TN) with real power, both the Forward Real Power and the **Reverse Power** blocking supervision features must be used. If the Reverse Power Blocking is not used, nuisance tripping could occur.

**Analysis:**

The M-3425A contains multiple elements to obtain stator ground fault protection. There is the standard 59N fundamental overvoltage element that provides 90%-95% stator ground fault protection. The 59N element can not be used to reliably detect faults near the generator neutral terminal. The 59N element can be used in conjunction with either the 27TN "Third Harmonic Undervoltage" element or the 59D "Third Harmonic Voltage Differential" element to obtain 100% stator ground fault protection. The 59N can also be used for backup protection in conjunction with the 64S element. The 64S element provides 100% stator ground fault protection using the low frequency injection method.

Due to the pitch of the generator stator windings, a third harmonic voltage is induced at both the generator terminals and the neutral voltage connection. The third harmonic voltage at the generator neutral decreases in the presence of a stator ground fault near the neutral end of a generator. Unfortunately, the third harmonic voltage may also decrease during conditions of low terminal voltage, low power output. In addition, special generator applications like synchronous condenser operations or pump storage applications may have an adverse effect on the third harmonic voltage level.

The variations in the 3rd harmonic profile under different operating conditions (plant startup, shutdown, synchronous condenser, pump mode, VAr sync) require the appropriate supervision(s) to block false operation. The following supervision methods are offered on the M-3425A; Forward and Reverse Power Block, Lead and Lag VAr Block, Lead and Lag Power Factor Block, and Definable Power Band Block.

In order to properly handle pump storage operations, the 3425A power blocking algorithm was changed from blocking anytime power is less than the setpoint to blocking from "zero per unit" to the forward power setpoint. During plant startup, after the field is flashed and before the unit is synchronized, small current measurement errors cause the measured power to fluctuate (typically <0.2%). This may result in a measured power value that is negative, (i.e., -0.001pu). If the reverse power blocking is not enabled, the 27TN may be momentarily unblocked, resulting in a relay operation and nuisance generator trip.

**Recommended Action:**

We highly recommend that if the Forward Power Blocking is used, both the Forward Power Blocking and **Reverse Power Blocking** be enabled and set. This setting is indicated in Figure 1, where the 27TN element will be blocked anytime real power is less than +0.3pu. The 3425A instruction book has been modified to include a similar note.

*APP Note #27*  
27TN Function Setting

The screenshot shows a software window titled "(27TN) - Third Harmonic UnderVoltage.Neutral". It contains several rows of settings, each with a numerical input field, a unit, and an enable/disable radio button. The settings are as follows:

Setting	Value	Unit	Enable/Disable
Pickup	1.3	0.1 V to 14.00 V	Enable (selected)
Pos. Seq. Voltage Block	80	5 V to 180 V	Enable (selected)
Forward Power Block	.3	0.01 PU to 1.00 PU	Enable (selected)
Reverse Power Block	-1	-1.00 PU to -0.01 PU	Enable (selected)
Lead var Block	-0.05	-1.00 PU to -0.01 PU	Enable (selected)
Lag var Block	0.05	0.01 PU to 1.00 PU	Enable (selected)
Lead Power Factor Block	0.05	0.01 Lead to 1.00 Lead	Enable (selected)
Lag Power Factor Block	0.05	0.01 Lag to 1.00 Lag	Enable (selected)
Hi Band Forward Power Block	0.05	0.01 PU to 1.00 PU	Enable (selected)
Lo Band Forward Power Block	0.05	0.01 PU to 1.00 PU	Enable (selected)
Delay	30	1 Cycle to 8160 Cycles	Enable (selected)

At the bottom, there are two groups of checkboxes: "OUTPUTS" (8, 7, 6, 5, 4, 3, 2, 1) and "Blocking Inputs" (FL, 6, 5, 4, 3, 2, 1). The "1" checkbox in the OUTPUTS group is checked. There is also an "Expanded I/O s" button and "Save" and "Cancel" buttons at the bottom right.

**Figure 1**

**Other Stator Ground Fault Protection Element**

The 59D element measures the ratio of the third harmonic between the terminal and neutral ends of the stator winding. Since the level of third harmonic at the terminal and at the neutral of the machine drops significantly for ground faults at or near the terminal or respectively at the neutral of the machine, a change in this ratio can be used to detect faults at the machine winding ends. A fault in the center of the winding does not appreciably affect this terminal/neutral ratio and thus this element can only be set to detect grounds in the top and bottom of the stator. The combination of the 59N and the 59D thus can cover 100% of the stator fault winding.

Since the terminal and neutral voltage will both exhibit the same low 3<sup>rd</sup> harmonic voltage for the operating conditions discussed, the 59D element does not require blocking supervision like the 27TN element. However, if the 3<sup>rd</sup> harmonic voltages are very small, the operate quantity may be below the pickup setting of the element. Thus the 59D element is more secure, but does not increase the reliability of the scheme.

An alternative to the 27TN and 59D elements on machines where the third harmonic profile is insufficient to be used for secure and reliable protection is the 64S element that operates by the low frequency injection method. This has been included on Beckwith relays in the European Market for the last decade. This method injects a low frequency signal through a filter into the stator through either the neutral grounding transformer secondary or a broken delta PT connection on the line terminals of the machine. The measure of the voltage and current of this injected signal reliably detects stator ground for 100% of the winding, even when the generator is off line.

*APP Note #27*  
27TN Function Setting

We apologize for any confusion or inconvenience the 27TN setting issue may cause. If you have any questions or require additional information, please contact your Beckwith Sales Representative or Beckwith Customer Technical Support, telephone number 727-544-2326.