Reverse Power Protection relay using microcontroller

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Abstract: A Reverse Power Relay is used to Monitor Generators while running in Parallel Condition. The Concept is When First Generator attains synchronous speed then it allows the next Generator to run to feed the power to the Bus. Now, Two Generators Feeds power to the Main Bus in the same direction. If anyone Generator meets any failure like Stator Failure then Prime Mover of the Generator acts as Motor [Like Getting Electrical Power and act Mechanical Power], Now Power From the Healthy Generator feed Power to the Failure Generator through Bus bar. This Action is termed as Motoring Action of the Generator. To Avoid 'Motoring Action', Reverse Power Relay should placed in individual Breaker Reserved for Generator. If Only one Generator in Action for your Plant, then it is not necessary to implement this Relay for the Protection Purpose. If Two Generators having different Rating with bus coupler, doesn't need Reverse Relay Protection. In the past, electromechanical relays were commonly used, now such relays have been replaced with high accuracy and high speed digital relays using Microcontrollers. Fast operation of relay is desirable, particularly for such type of faults which could lead to system blackout. Digital relays offer other advantages also, in term of multiple variable settings and compact size.

Keywords -- Reverse power relays, Relay Modeling, Digital relays.

I. INTRODUCTION

Protection relays play a very important role in the safe and reliable operation of power system. Insecure or failed protection systems may make the situation worse and lead to the system blackouts. All faulted conditions do not lead to such situations. A fault that causes such situations include N-1 contingency of line, overloads, reverse power flow (loss of mechanical input) and others [1]. A typical protection scheme is an arrangement of various types of relays such as over current, short circuit relay, over-under voltage, over- under frequency relays and others. In 90's, most of the relays in power system were electromechanical, later on replaced with solid-state. Now both types of relays are being replaced with digital relays. Digitals relays offer advantage of fast in operation, small in size and reliable in operation in case of power system fault [2-3]. The relay also offers advantage in terms of their sensitivity and wide range controlling.

II. REVERSE POWER RELAY (ANSI CODE - 32)

Reverse Power Relays (RPR) are commonly used in power system for detecting motoring action of synchronous generator. This condition normally occurs when the prime mover (engine or turbine) fails, however the field winding is still connected with the excitation system. This resulted in motoring action and the machine behaves like a synchronous motor connected with large power system. In such condition, the turbines become the active load on that machine. Motoring action draws power from the system to drive the prime mover and can cause severe damage to the prime mover. This condition is not desirable and there is an objectionable temperature rise in case of steam turbine. Therefore such conditions need to detect quickly and the GCB should be tripped. Diesel engines and gas turbines are less susceptible to immediate damage, but unburned fuel may present a fire or explosion hazard.

III. MOTORING OPERATION

A generator is driven as a synchronous motor by the power system to which it is connected when the mechanical power input to its shaft from the turbine is lost. While the generator excitation system is active, the generating unit tends to drive its prime mover at synchronous speed. Motoring mode of operation has destructive effect on the prime mover but the coupled generator would not be affected. A Protection device/function that monitors the power flowing into the synchronous machine can sense this condition. Magnitude of motoring power drawn by the machine depends on the type of prime mover which in turn decides the sensitivity requirements of the anti-motoring function.

IV. CONCEPTS OF ANTI-MOTORING PROTECTION

Motoring conditions can occur due to operator‟s mistake during synchronization with machine speed slower than the power system; circuit breaker failure to open during unit shutdown or due to a mechanical breakdown. Both electrical and mechanical anti-

motoring protection systems are usually implemented in majority of the power plants. Electrical anti-motoring protection is implemented by a directional sensing reverse power relay that senses reversal of the power flowing out of the generator terminals. Motoring power requirements at of any generation unit is a function of windage and frictional losses of the prime mover and rotor in association with the power losses in the generator. The anti-motoring protection operates to isolate the generator and prime mover from the power system. Typical motoring power requirements for different types of generating units are as follows

Table 1 Typical motoring power requirements

Steam turbines a) Condensing types b) Noncondensing type	 1%- 3% +3%
Hydraulic Turbines a) Impulse type b) Reaction type	.20% - 2+% +/- 25%
Diesel engines	+/- 25%
Gas turbines	50+ %

Various detection means are provided as part of the generator and its control, but supplementary reverse power protection device/function (ANSI 32) is recommended. Sensitive numerical relays with sensitivities down to 1 mA would be necessary when a generating unit is operating on part load. Selection of CTs and PTs instrument transformers along with their interconnecting cables needs special attention in such cases. Theoretically, an anti-motoring device, whether monitoring for secondary watts or current, compute power requirements of the generating unit as: $P = I * E \cos \theta$

Where E and I refer to line to line quantities and Θ is the power factor angle.

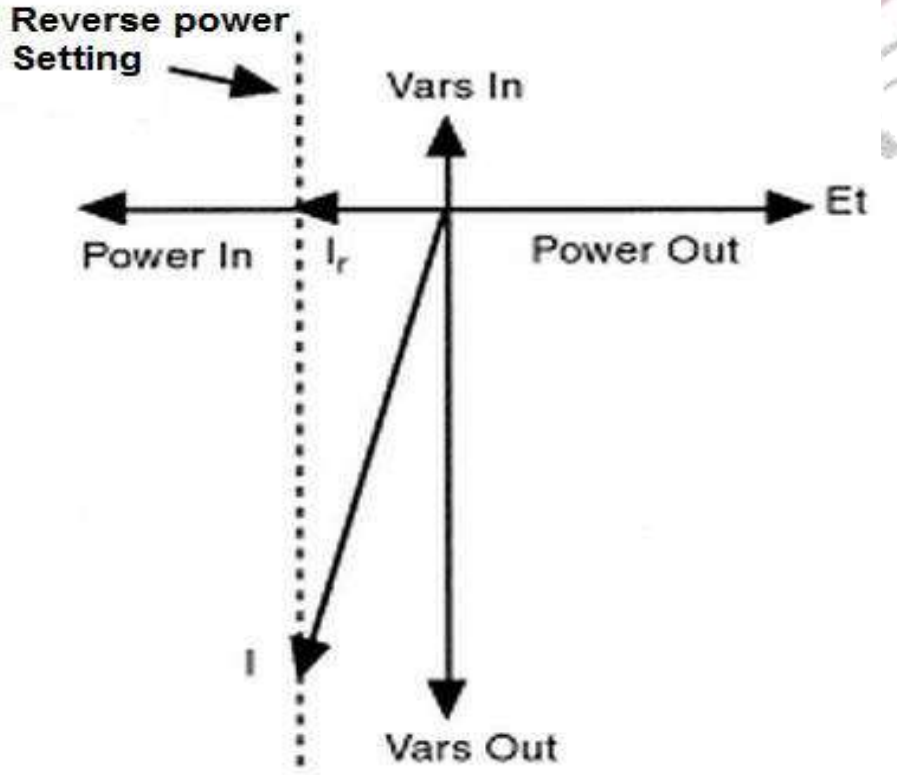

Fig. 1 Reverse power measurement principle

A directional element is used in anti-motoring protection function which serves the purpose of detecting the abnormal direction of power flowing into the generator terminals. Directional elements are particularly useful when the system has several sources, which in our case is the generating unit and the transmission grid network. The directional change in power flow is sensed by measurement of phase displacement between current and voltage.

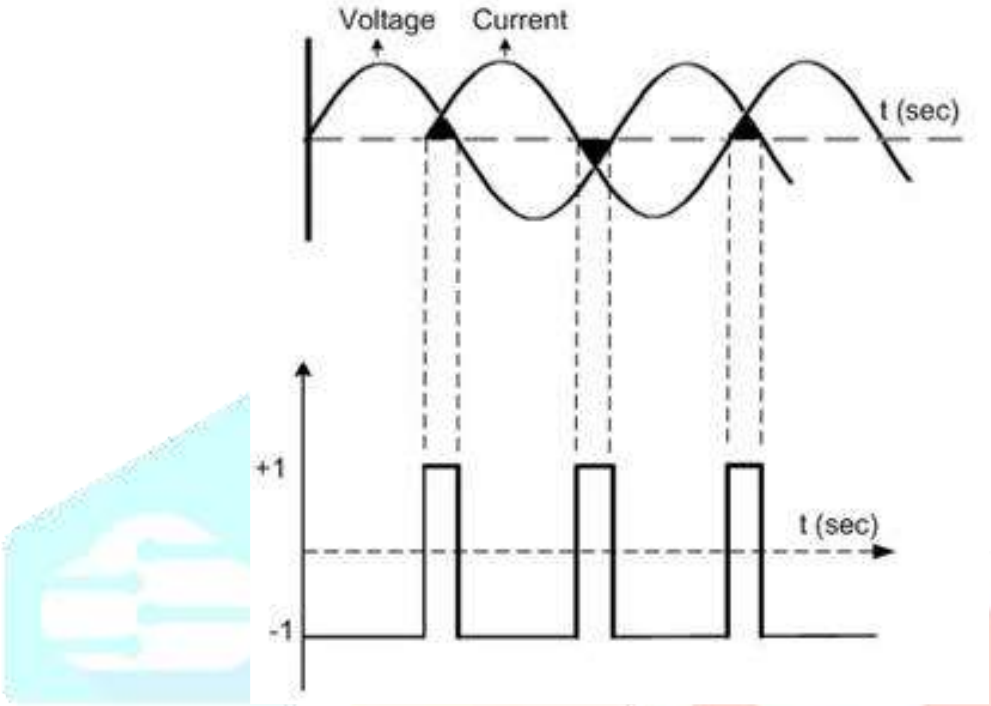

Fig. 2 Phase displacement between current and voltage during fault

IV. PRINCIPLE OF REVERSE POWER RELAY

A reverse power relay is a directional relay that is used to monitor the power flow from generator (running in parallel with another generator or the utility) and in case of abnormal condition take appropriate action. Under abnormal condition, the direction of power changes from the bus bar into the generator. This condition normally occurs when prime mover fails. The real power drawn from the grid is quite small compared with the generator rating. However stator current undergoes 180" phase shift normally referred as Maximum Torque Angle (MTA) this suggests that if we use a directional relay with MTA of 180" (using generator
phase angle conventions) then it could detect the loss of prime mover as the current phasor would reverse and enter the trip region. However the magnitude of this reversed current phasor is quite small compared to the forward current as the generator draws just enough real power to meet the losses and drive the turbine. Hence, the directional relay for detecting the loss of prime mover needs to have a high degree of sensitivity compared to directional relays used for over-current application.

The installation of RPR on a power system is shown in Fig.

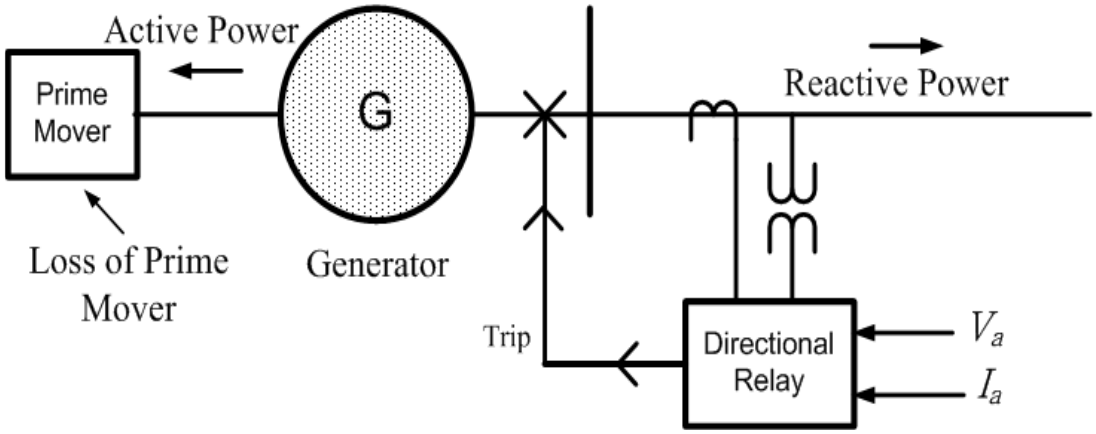

Fig.3. Reverse Power Relay in Power System

For applications where a protection sensitivity of better than 3% is required, a metering class CT should be employed to avoid incorrect protection behavior due to CT phase angle errors when the generator supplies a significant level of reactive power at close to zero power-factor. The reverse power protection should be provided with a definite time delay on operation to prevent spurious operation with transient power swings that may arise following synchronization or in the event of a power transmission system disturbance.

V. CONCLUSION

Generation utilities with large generating units usually deploy integrated, multifunction numerical protection relays for protecting their generators during emergencies. Typical generator multifunction relay can host several protection functions such as differential, stator earth fault, back up impedance, rotor earth fault etc included in one compact single package. Amongst all these protection functions two protection functions viz., anti-motoring protection have been discussed. An integrated model comprising of a Reverse Power relay using Microcontroller has been developed. The results prove that the protection functions are found to be performing as intended.

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