[Mansoura Engineering Journal](https://mej.researchcommons.org/home)

Volume 5 | Issue 1 Article 4

7-6-2021

Simplified Techniques for Solid - State Protection in Power Systems - Differential and Overcurrent Relaying.

Ahmed Mohamed Hassan
Assistant Professor, Electrical Power & Machines Department, Faculty of Engineering, Mansoura University, Mansoura, Egypt.

Recommended Citation

Mohamed Hassan, Ahmed (2021) "Simplified Techniques for Solid - State Protection in Power Systems - Differential and Overcurrent Relaying.," *Mansoura Engineering Journal*: Vol. 5 : Iss. 1 , Article 4.
Available at: https://doi.org/10.21608/bfemu.2021.182373

SIMPLIFIED TECHNIQUES FOR SOLID - STATE PROTECTION IN POWER SYSTEMS - DIFFERENTIAL AND OVERCURRENT RELAYING

by

Ahmed Abdul - Maguid Hassan , B.Sc., M.Sc., Ph.D *

ABSTRACT :

The paper presents simplified techniques for solid-state protective differential and overcurrent relaying in power systems. The labororatory-experimental investigation of the developed schemes showed efficient results. The presented schemes are simple, compact, reliable and very much cheap in comparison with conventional electromagnetic relaying techniques. These techniques are much suitable for digital protective applications.

I. INTRODUCTION :

System protection is an important phase in electric power engineering. Faults or any abnormal condition on a power system must be removed in the minimum of time. Protective relays are used to detect abnormal currents and voltages and, when detected, to open the appropriate circuit breakers.

In protective relaying practise, the most critical factors are fault detection and the high operating speed required. There are many varieties of automatic protective systems ranging from simple overcurrent electromagnetic relays to sophisticated electronic systems (References 1-8).

---

* Author is with the Electrical Engineering Dept., Faculty of Engineering, El - Mansoura University, Egypt.

Mansoura Bulletin , Vol. 5, No .1 , June 1980

The objective of th..s research work is to introduce simple,compact solid-state protective relaying schemes which can be effectively used for differential or overcurrent protection in power system.

The basic principle of differential protection is that current values at two (or more) points on a system can be continuously balanced by, a suitable relay or relays so that as long as the currents at both points are equal and are in phase, this balance will hold and no tripping will ensue. If, however, a fault disturbs the balance, the relays can be made to trip the faulty circuit. This basic principle is schematically shown in Fig. (1).

The basic principle of overcurrent protection is that the relaying system should isolate the protected zone when the current exceeds a pre-specified value.

Accordingly, the heart of any protective scheme is the relaying system which is commonly electromagnetic in principle. Solid-state devices are now evolving in the field (References 2-8).

2. THE BASIC STRUCTURE OF A SOLID-STATE RELAYING DEVICE

Recent trend in relay desing is getting towards the complete elimination of moving parts. The current tremendous progress in solid-state electronics and technology makes the achievement of this end possible. The use of solid-state relaying devices has resulted in the substitution of fewer, simpler and more reliable elements.

The attrachion of solid-state devices is the possible reduction of maintenance and the consequent need for fewer highly trained personnel to carry out such maintenance. An equally important advantage is the very much lower VA burden of such devices, and therefore, much less stringent current-transformer requirements.

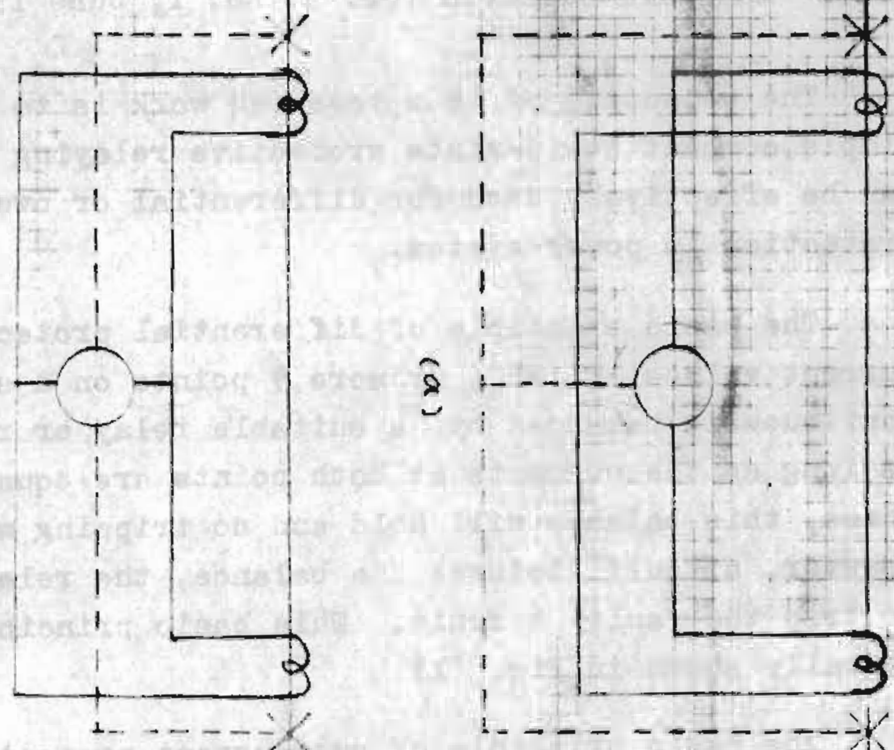
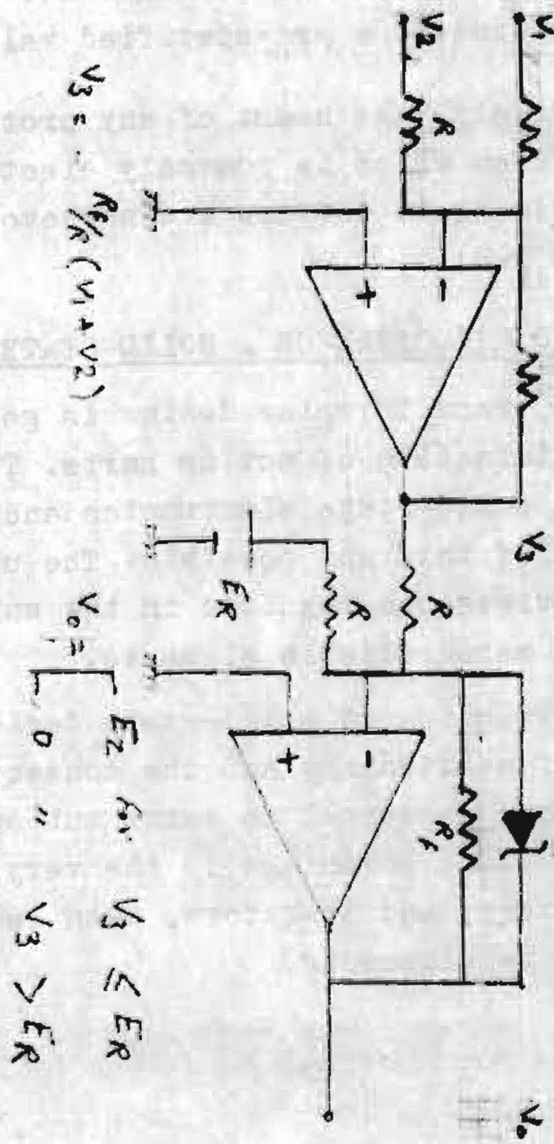


Fig. 1 : Differential Protection
(a) Using Opposed Voltage
(b) " Circulating Current



Summer-Inverter
Zener-Diode Comparator

Fig. 2 Detector Element

Solid-state relaying equipment can be designed to plug-in to a base, so that it can be readily replaced if it should prove to be faulty. Such equimpent are much smaller than conventional relays. This compactness is important in effecting considerable economy in the housing of the equipment.

The two basic principles of differential and overcurrent protection have stimulated the adoption of a very simple solid-state circuit using an operational amplifier in a summer-inverter configuration cascaded by a comparator circuit as shown in Fig. (2).

The operational amplifier summer-comparator circuit shown in Fig. (2) is used to detect any inequality between V_1 and V_2 signals for differential relaying according to the following relations :

$$V_3 = - R_f / R \ (V_1 + V_2)$$

$$V_o = \begin{cases} E_z & \text{for} \quad V_3 \leqslant - E_R \\ o & \text{for} \quad V_3 > - E_R \end{cases}$$

Where,

V_1 and V_2 are oppositely analog-voltage signals from current transformers .

V_3 is the input signal to the Zener - diode comparator.

V_o is the detected signal.

For over-current relaying, the use of the second - stage of the circuit shown in Fig.(2) is sufficient.

The detected signal should operate an electronic switch which can actuate the tripping circuit.

3. EXPERIMENTAL RELAYING - SCHEMES USING THYRISTORS

The use of the basic solid-state relay of Fig.(2) for differential or overcurrent proteotion necessitates the presense of suitable sensing and tripping circuits.

Sensing circuits should simply be derived via the common-used current transformers. For much flexible operation, this maybbe done using a proper potentiometer. In Fig.(3), potentiometers in the current-transformer circuits are used to compensate any inequality in current transformers, to provide adequate sensing signals and to enable the experimental investigation of the schemes.

Tripping circuits are efficiently designed using thyristors as shown in the arrangements of Fig. (3)

4. PROPOSED RELAYING - SCHEME USING TRIAC-ON-OFF CONTROL

A proposed relaying scheme is set up.The basic principle of it is to replace the conventional relay and trip circuits by Triac ON-off controlled circuits. In this arrangement the output of the detector should be able to actuate the triac ON-off controlled circuit .

Basic schematic diagram of a differential relaying using triac on - off control for single-phase systems is shown in Fig. (4).

The proposed scheme of Fig.(4) replaces the conventional differential protection. In this arrangement two identical signals from the two current transformers via potentiometer are conducted to the operational - amplifier detector, the output of which operates a UJT - relaxation oscillator which feeds the gate circuits of triacs.

During normal operation (triacs are on), the triacs receives high-frequency gate pulses which turn it on in every half-cycle. These pulses are obtained from the UJT-oscillator. It should be noted that firing circuits required to operate triacs in series must have isolated outputs, each capable of providing the required triacgate drive. Resistors R are essential to prevent a triac with low gate-impedance shunting current away from the remaining devices.

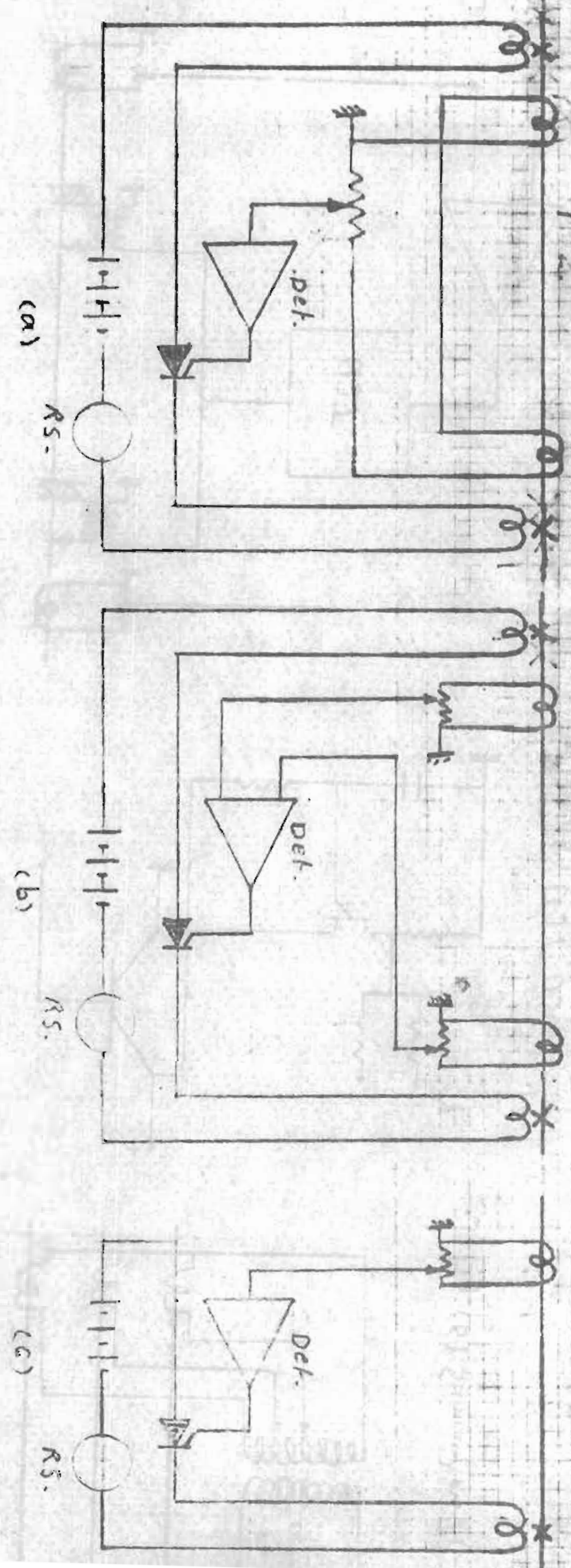


Fig.3 Proposed Schemes for differential and Overcurrent Protection

Det. = Detector   RS. = Reset Switch

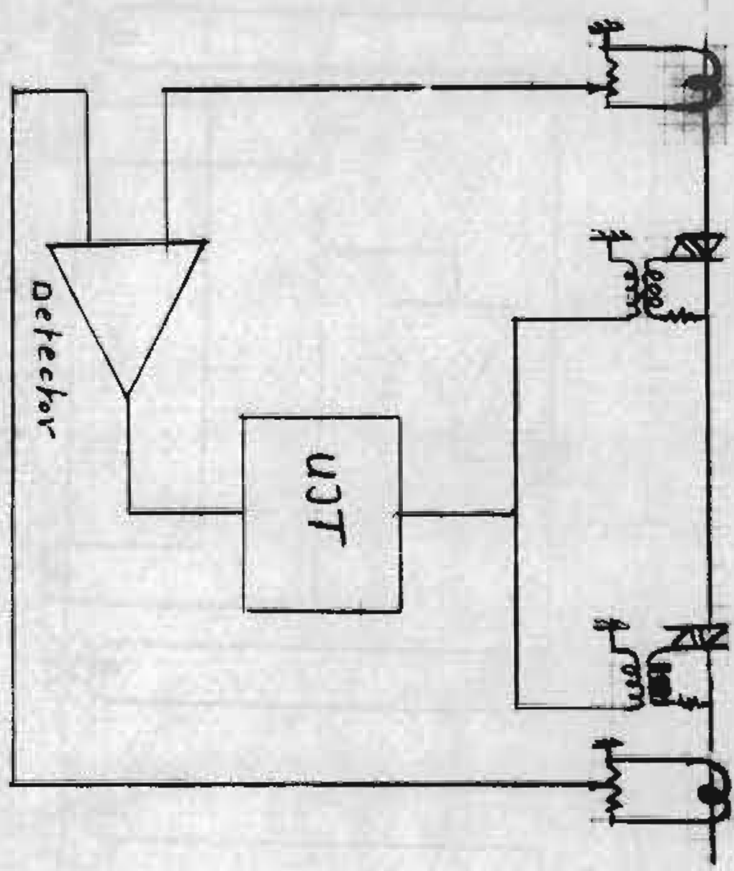


Fig.(4) Differential Protection Using Triac On-Off Control

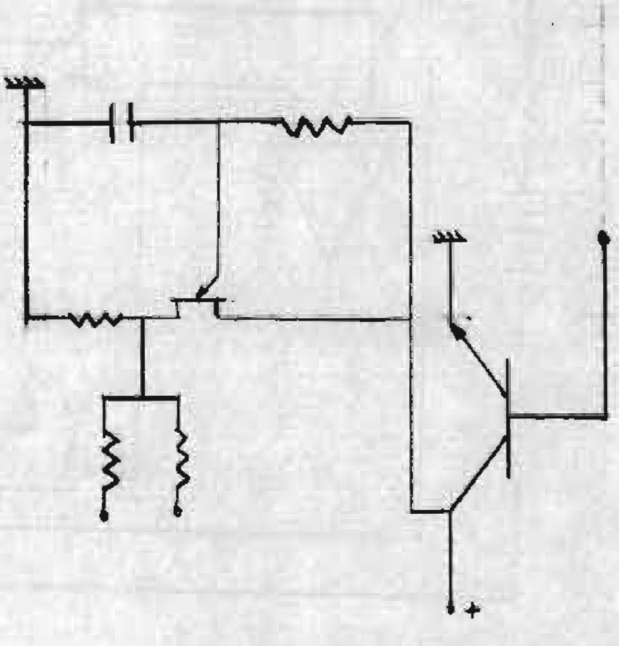


Fig.(5) UJT oscillator and Switch

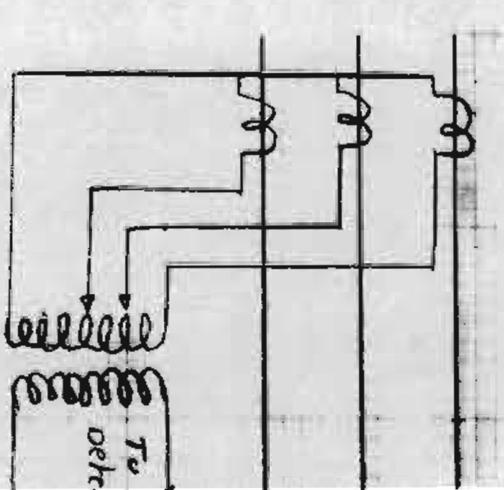


Fig.(6) Summation Tr.

During any abnormal condition, the pulses are cut off, and the triacs will isolate the protected zone.

Fig.(5) shows the UJT-relaxation oscillator circuit used with the proposed scheme. The presense of the detector signal puts the UJT-oscillator off (during abnormal condition).

5. Discussion and conclusions

The presented relaying schemes in this paper have all been experimentally investigated. The investigation showed satisfactory laboratory results and performance.

The detector of Fig. (2) responds at any abnormal condition within a time of a full-cycle (i.e. within 20 msec.(typical fault clearance time in h.v. systems is 140-80 ms). This time can be reduced to 10 ms when a full-wave rectifier bridge is introduced between the summer-inverter and the comparator. These clearing times show how fast the system will respond at any abnormal condition.

For three-phase protection using proposed techniques, it is only required to replace the single-phase current transformers with summation transformers, the schematic diagram of which is shwon in Fig. (6).

Other additions have been made during the working order of the project such as the replacement of the thyristor-circuit in Fig.(3) by a thyristorized regulated Dc-power supply. The application of a thyristorized dc-power supply for the trip circuit, switches the trip circuit off after the isolation of the faulty part.

Transistorized drivers (amplifiers) may be used between detector and thyristor-gates in Fig. (3) to provide suitable triggering means if the detector signal fails to do so (this depends on ratings of thyristors used.)

The protection scheme of Fig.(5) can easily be implemented for overcurrent protection .

Owing to the recent limitations of thyristors for high-voltage high-power applications, it is felt that protection schemes based on that given in Fig.(4) are much convenient for such application, whereas protection schemes based on that given in Fig.(5) are much suitable for medium power, medium voltage applications.

Conclusively, the presented schemes are simple, compact and very cheap methods for protective relaying in power systems. It is much suitable for interactive digital protection. Therefore, further achievements in the field are expected.

REFERENCES

(1) The Electricity Council, "Power System Protection, volume 1 ", Macdonald and Jane's, London, 1975.

(2) G.Potisk, " Static Protection Equipment for Busbars",Brown Boverie Rev., No.7 (1971), P. 317.

(3) J. Boniger, " Solid-state overcurrent-Time Relays", ibid, P.312.

(4) R. Wanner, " Protection of large Generators", ibid, P.257.

(5) O.E Baker, " Solid-state Remote controllers for Electrical systems" , Westing hons Eng., 31, No.5, sept (1971), P.135.

(6) R.F Blake, " Designing solid-state static power Relays, Electronics, May, 1960.

(7) R. Langfelder, " Desig of static Relays for signalling & control", Electronics, July, 1960.

(8) R.L. Kahler and others, " Asimple overcurrent protection circuit for a High voltage laboratory. " IEEE - TRANS-on instrumentation and measurement June, 1976, P 161.