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A study of the induced voltage detector designed for the power distribution system on 115 kV effecting on 22 kV distribution line

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Abstract

This paper presents a study of the induced voltage detector designed in the power distribution system on 115 kV that effecting on 22 kV distribution line. Therefore, the studies are the induced voltage detector design and construct of the power distribution system on 115 kV, which affects the power distribution system on 22 kV and the operation has been its ease of use, check voltage that can be rendered into sound and the lights. The red light the result of the 22 kV distribution line and a green light the result of induced voltage of the power distribution system on 115 kV.

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Keywords: induced voltage detector, electric distribution system

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1. Introduction

Today Electricity Authority at Provincial Electricity Authority (PEA) has distribution systems 22 kV equipped with 115 kV transmission system with the structure shown in Figure 1. Transmission 115 kV is mounted on top of the transmission line 22 kV. When the system size 22 kV power distribution due to power outages. The need to perform 22 kV power outages. The operators where touch to 22 kV cable system could be directly harmed by the induced voltage of the power system 115 kV. [1]

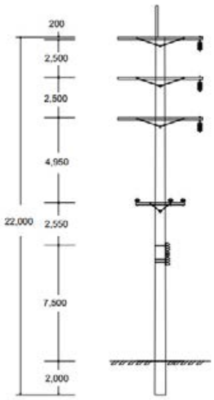

Fig. 1. The structure of the power distribution system on 115 kV with the power distribution system on 22 kV.

Nowadays, voltage detector that PEA applications are not able to monitor and identify the voltage of the power distribution system 22 kV or the voltage induced by the electrical system 115 kV. The procedure for performing assigned stopped power and shock Ground head - end and at work place. Before touching the high voltage transmission lines directly. If voltage of 22 kV power distribution system in line. Because of the cutting wrong circuit. This will cause a severe explosion when the short grounding. The operator will be harmed by the fire of the explosion.

Therefore, the research team was aware of the problem and life safety of the operators. For this reason, the research team created a concept device that can identify the voltage of 22 kV power distribution system or a voltage induced by the 115 kV transmission line.

2. Electrostatic Coupling theory.

This configuration can be explained by capacitive coupled circuit shown in Fig. 2. The mutual capacitance is a function of the distance between the two conductors, their height above ground, and the length that they are paralleled. Both conductors closer to one another with a larger the mutual capacitance will be. The capacitances to ground of the two conductors and are primarily a function of height above ground and a conductor, especially its diameter. The voltage induced in the conductor due to the voltage applied to the conductor can be found by dividing the voltage as shown. [2]

$$V_{bg} = \left(\frac{C_{ab}}{C_{ab} + C_{bg}} \right) \times V_{ag} \tag{1}$$

The unit is in farads per meter. It can be seen that the unit of length is canceled. So the distance that the two lines are parallel does not affect the magnitude of the induced voltage. This is contrary to the induced magnetic field, that the lines are parallel to has a dramatic impact on the induced voltage. [3]

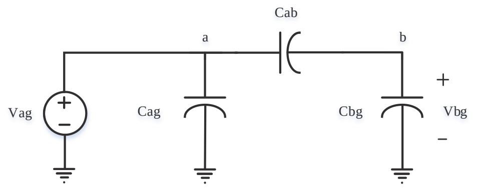

Fig. 2. Capacitive coupling circuit.

3. Induced voltage detector design.

For the problems mentioned, the conventional voltage detector can't differentiate between the 22 kV distribution line and induced voltage by electric field from 115 kV because output display was not clear and Impact on operators confusing in practice.

The results of the research of PEA found that the power distribution system on 22 kV are different to the induced voltage of the power distribution system on 115 kV as shown in table 1. In the table 1. shown a comparison between the induced voltage and power distribution system and Fig. 3. shown block diagram of the induced voltage detector. Which can be categorized as the follow in 3 parts. The part 1 is detection and protection in this part has the amplifiers and clamper circuit. In the part 2 is central processing unit and part 3 is output display.

Table 1. A comparison between the induced voltage from 115 kV and power distribution system on 22 kV.[4]

Conditions prescribed	Based voltage
Induced voltage by electric field from 115 kV (line to ground)	5-7 kV
Power distribution system on 22 kV. (line to ground)	12.7 kV

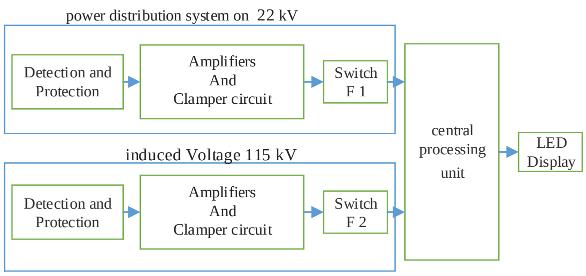

Fig. 3. Block diagram of the induced voltage detector.

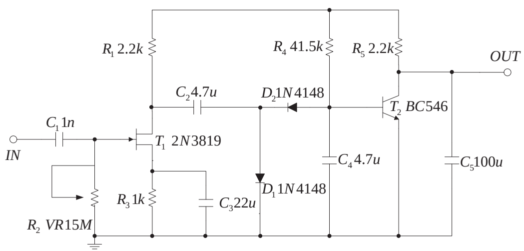

Fig. 4. Voltage detector circuit.

In the design of induced voltage detector using the basic principles of JFET amplifier. As shown in Fig. 4. The driver circuit of transistor are using Fixed Bias Circuit because the simplest model bias. Which consideration are static biasing circuit, while there are no input signal. The capacitor C1 is coupling of input signals into the base-pin of the transistor, it make the base current changes to the input of transistor. And the collector current will be variation to base current and make output signals is larger than input and will be released to capacitor C2.

Fig. 4. Base resistances (R_b) is the resistance configure base current (I_b) by the JFET amplifier bias current directly to Base pin and compared with Emitter pin of transistor. When the I_b flow through will make collector current (I_c) flow through of transistor. And the flow current will make the junction resistance between the collector and emitter decrease and I_c will be Increase current. If V_{be} is unchanged, I_b will be Increase More constantly and then I_c will flow through increase more constantly as well.

3.1 Detection and protection.

As part of the detected signal and protection electronic equipment have operating which are receiving electric field distributed around conductor and protecting equipment damage from 22 kV voltage. Design of protection set of electronic equipment to use a plastic role. Superlene size 8 mm. thick, to prevent the electronic equipment contact with the distribution system. As shown in Fig. 5

Fig. 5. shown the amplifier and clamper circuit has two parts : the part 1 is amplifier and clamper circuit from the power distribution system of 22 kV and the part 2 is amplifier and clamper circuit from the induced voltage from 115 kV. When the conductor have been electric field the amplifier circuit of both will lead the field to expand to a larger signal to drive the switch F1 and F2. The switch F1 and F2 are the JFET equipment, because of a JFET equipment is high input impedance and high sensitivity of the signal due to the electric field is small signals (Unit v/m), it requires a device with high sensitivity. For the Fig. 6. shown the actual protection distance of the electronics equipment.

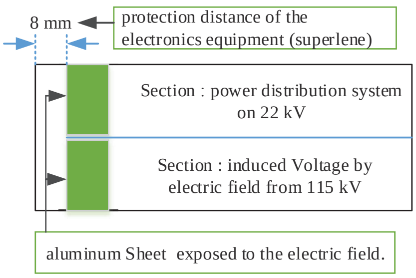

Fig. 5. Section element of protection distance

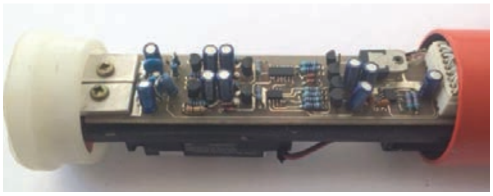

Fig. 6. Protection distance of the electronics equipment.

3.2 Central processing unit.

Table 2. The processing conditions.

Input		Output	
A	B	F1	F2
0	0	0	0
0	1	0	1
1	0	1	0
1	1	1	0

The central processing unit is responsible from the output detected signal of both parts are processed according to the conditions and forwarded to the output display. The digital circuits are designed for use in comparison with the results of both the signal processing detection to meet the conditions, and then forwarded to the output display. As shown in table 2.

For the table 2. when the processing conditions designed are input and output. And then took the results to design a digital logic gate. Which are will be $F_1 = (A\bar{B}) + (AB) = A$ and $F_2 = \bar{A}B$. Which selection digital logic gate IC is number 7400. As shown in Fig. 7.

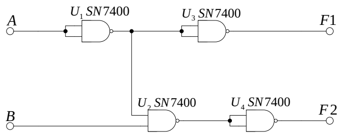

Fig. 7. Actual processing circuit.

3.3 Output display.

For the output display, it will has the output display of two parts, sound and lighting with the operating conditions are as follows in table 3.

Table 3. Output display.

Central processing unit		Output display		
F1	F2	Red	Green	Buzzer
0	0	off	off	off
0	1	off	on	off
1	0	on	off	on
1	1	on	off	on

When the output of the central processing unit :

- F1 is Logic Hi, when the detected voltage is 22 kV distribution line and the red LED on and buzzer on and then the green LED off, respectively.
- F2 is Logic Hi, when the detected induced Voltage of 115 kV and the red LED off and buzzer off and then the green LED on, respectively.

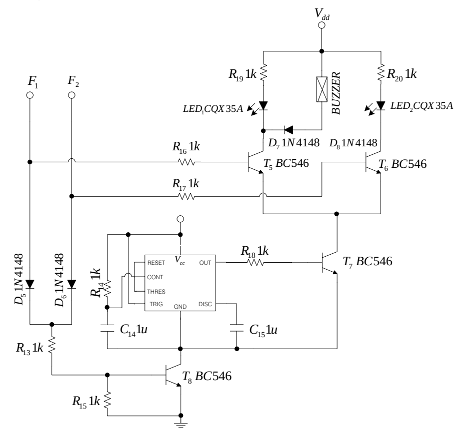

Fig. 8. Output display circuit

Design output display circuit are used transistor to drive the LED light and BUZZER and IC number is number NE 555, as shown in Fig. 8 and Fig. 9. shown the front of the actual inducted voltage detector.

Fig. 9. The front of the induced voltage detector

3.4 Printed circuit board design

Printed circuit board (PCB) design divided into two layers: the top and the bottom, as shown in Fig. 10. Which are used for installation of elements as follow : the detection, protection, amplifier, clamp circuit, central processing unit and output display, respectively.

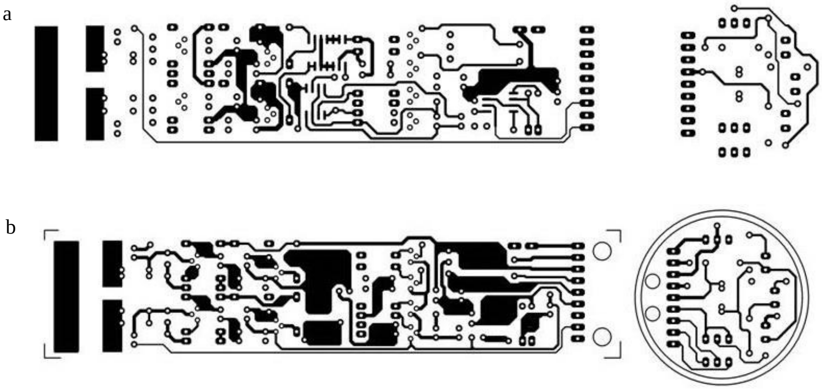

Fig. 10 (a) The top of PCB design of actual induced voltage detector; (b) The below of PCB design of actual induced voltage detector

4. The experimental results.

4.1 The experimental results for the resistance in amplifier circuit.

The testing the induced voltage detector design is creation. As shown in Fig. 11. shown the tested for appropriate resistance voltage transformer required to reduce the voltage to suit the test.

Fig. 11. Induced voltage detector.

a b

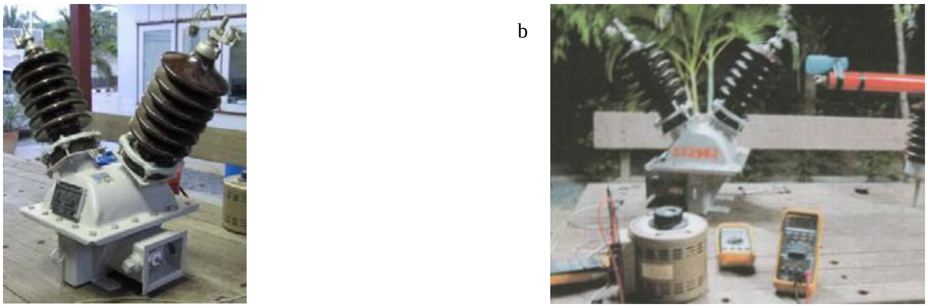

Fig. 12. (a) Voltage transformer; (b). Measure output voltage of the voltage transformer.

Table 4. The experimental results of the resistance for 2 parts.

No.	Resistance		V_{IN} (V)	V_{OUT} (kV)	Display		Output result
	22 kV	Induced 115 kV			22 kV	Induced 115 kV	
1	1 M	18 M	40	8.0	no	yes	no
	1 M	18 M	65	13.0	yes	no	no
2	1.5M	22 M	35	7.0	no	yes	no
	1.5 M	22 M	58	11.6	yes	no	no
2	2 M	30 M	27	5.4	no	yes	no
	2 M	30 M	54	10.8	yes	no	no
6	2.5 M	34 M	17	3.4	no	yes	no
	2.5 M	34 M	51	10.2	yes	no	no
3	3 M	34 M	17	3.4	no	yes	exactly
	3 M	34 M	45	9.0	yes	no	exactly
9	3.5 M	34 M	17	3.4	no	yes	no
	3.5 M	34 M	38	7.6	yes	no	no
4	4 M	34 M	17	3.4	no	yes	no
	4 M	34 M	30	6.0	yes	no	no

For the voltage transformer at rated 22000/110 V, as shown in Fig. 12. (a) In this test will use a variable transformer range 0-220 V, 5A connected to the secondary winding of the voltage transformer and measure output voltage of the primary winding of the voltage transformer from 1 - 22 kV, as shown in Fig. 12. (b)

In an experiment to the appropriate resistance a suitable for use in amplifier circuit in the order to voltage measurements of both part, can be seen from table 4. Which the experimental results of the appropriate resistance in amplifier circuit and the resistance value using measure induced voltage from 115 kV will use resistance value is 34 MΩ and the work started at induced voltages of 3.4 kV, as in Fig. 13.

In the Fig. 14. shown the measure of the power distribution system on 22 kV will use resistance value is 3 MΩ and the work started at voltages of 9 kV, respectively.

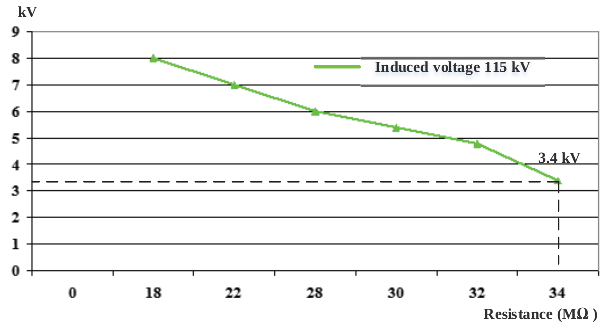

Fig. 13. The relationship between the resistance and the induced voltage from 115 kV.

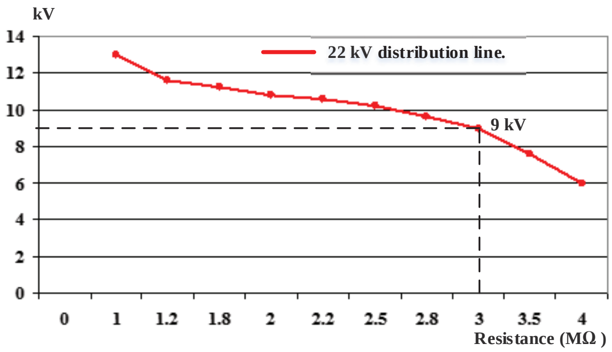

Fig. 14. The relationship between the resistance and 22kV distribution line.

4.2 The experimental results of the induced voltage detector on 22 kV distribution line of the PEA.

The measured induced voltage detector to actual applications that the PEA official, Doem Bang Nang Buat, Suphanburi, as shown in Fig. 15.

Fig. 15. (a) shown the results of the measured induced voltage from 115 kV and Fig. 15. (b) shown the green LED is on because detected induced voltage from 115 kV and Fig. 15. (c) shown the measured of 22 kV distribution line and then Fig. 15. (d) The red LED on because detected power distribution line on 22 kV will be seen that from all the tests 15 times As shown in Table 5 and 6, Respectively.

In the table 5. shown the measure of induced voltage detector from 115 kV for the measured 15 times the green LED on and the red LED off and then buzzer off, respectively. It can be concluded that the induced voltage detector from 115 kV is actually.

For the table 6 shown the measure of 22 kV distribution line from the measured 15 times the red LED on and the green LED off and then buzzer on, respectively. And the Fig. 15. (c) and 15. (d) shown the results of the measure of the power distribution line on 22 kV will be seen that from all the tests 15 times.

It can be concluded that, the induced voltage detector can be measured induced voltage from 115 kV and power distribution line on 22 kV are actually.

Table 5. The measure induced voltage detector from 115 kV of the PEA.

No.	Output display		
	LED lamps		Buzzer
	22 kV Red LED lamp	Induced 115 kV Green LED lamp	
1	off	on	off
2	off	on	off
3	off	on	off
4	off	on	off
5	off	on	off
6	off	on	off
7	off	on	off
8	off	on	off
9	off	on	off
10	off	on	off
11	off	on	off
12	off	on	off
13	off	on	off
14	off	on	off
15	off	on	off

Table 6. The measure voltage detector of 22 kV distribution line of the PEA.

No.	Output display		
	LED lamps		Buzzer
	22 kV Red LED lamp	Induced 115 kV Green LED lamp	
1	on	off	on
2	on	off	on
3	on	off	on
4	on	off	on
5	on	off	on
6	on	off	on
7	on	off	on
8	on	off	on
9	on	off	on
10	on	off	on
11	on	off	on
12	on	off	on
13	on	off	on
14	on	off	on
15	on	off	on

Fig. 15. (a) The measured induced voltage from 115 kV; (b) The green LED on because detected induced voltage from 115 kV; (c) The measured of 22 kV distribution line; (d) The red LED on because detected power distribution line on 22 kV.

5 .Conclusion

The creation of the induced voltage detector design can be differentiated between the 22 kV distribution line and induced voltage from 115 kV. Which after testing the detector for 15 times, it showed that it has its accuracy and stability. This can reduce the risk of exposure to electrical shock upon shock ground before practice and enhance the confidence of the personnel.

6. Acknowledgment

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