

## On-line monitoring using Bushing or CT capacitor taps.

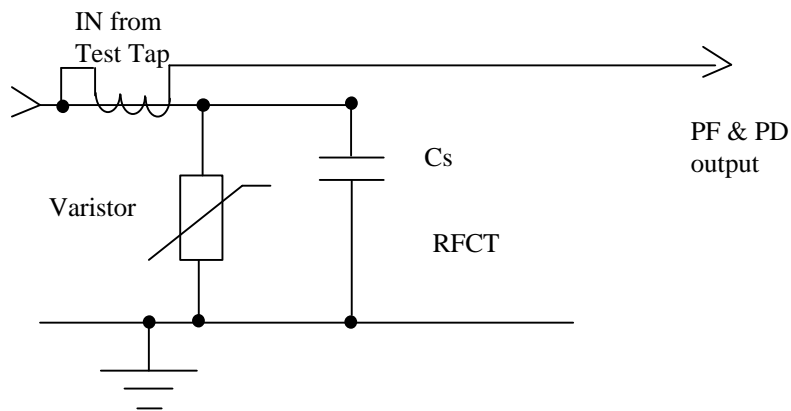
The ANSI type capacitor taps always grounded during operation. The lost of ground will lead to appearance on the capacitor tap the voltage up to 17 kV. In the case of using capacitor tap as a point for connection for on-line bushing power factor testing/monitoring the sensors connected to the capacitor tap should:

- protect operation personnel from electric shock in the case of the open test tap circuit;
- protect test tap from overvoltage in the case of open test tap circuit;
- provide reliable current output from the test tap.

### Bushing sensors

Mainly there are three different types of bushing sensors:

#### 1. Capacitor type sensor

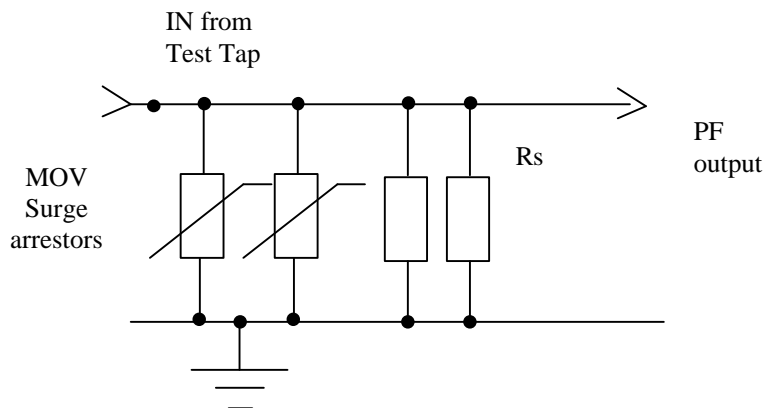


In the case of 500 kV bushing that has C1 capacitance equal to 300 pF the output voltage when the test tap circuit is open will not exceed:

$$U_{out} = \frac{U \cdot C1}{\sqrt{3} \cdot Cs} = \frac{500 \cdot 10^3 \cdot 300 \cdot 10^{-12}}{\sqrt{3} \cdot 1.08 \cdot 10^{-6}} = 80V$$

This sensor has two levels protection; the first one is capacitor that reduces output voltage to the safe level and the second one the varistor that protects from spikes coming from overhead line.

#### 2. Resistor type sensor

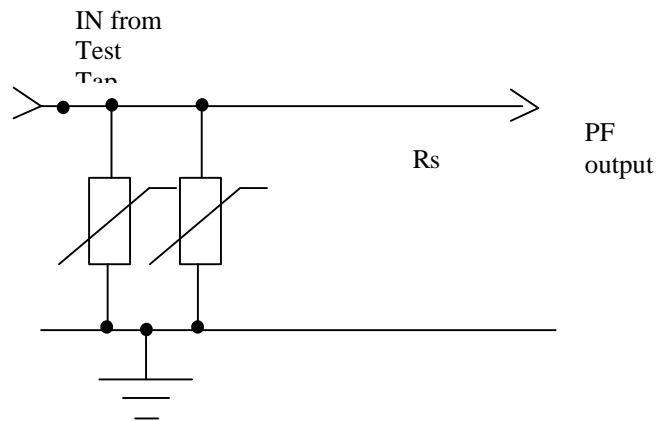


In the case of 500 kV bushing that has C1 capacitance equal to 300 pF the output voltage will not exceed:

$$U_{out} = \frac{U \cdot w \cdot C1 \cdot Rs}{\sqrt{3}} = \frac{500 \cdot 10^3 \cdot 314 \cdot 300 \cdot 10^{-12} \cdot 2000}{\sqrt{3}} = 54V$$

This sensor has two levels protection, the first one are resistors that reduce output voltage to the safe level and the second one MOV surge arrestors that protect from spikes coming from overhead line.

### 3. MOV arrestor's sensor



The sensor has only one level of protection. In case of open circuit all voltage is applied to the arrestors. The safety margin depends on how long the arrestors can withstand applied voltage. This design can not reliably protect the operation personnel from electric shock or protect the bushing from failure in the case of lost grounding circuit of the capacitor tap.

### Using common data acquisition unit to monitor multiple installation (several power transformers).

It is a common knowledge that voltage potential between different apparatus at substation during switching or lightning surges may be as high as several KV. While bringing signals from different apparatus to the same monitor, special care should be taken to protect the operation personal and measuring equipment.

It can be achieved by:

- a. Using isolation current/voltage transformers for signal source at measuring point with appropriate primary to secondary isolation level
- b. Using appropriate covers/connectors to prevent an access to signal connecting boars/connectors/terminals while equipment is energized.

- c. Protect all circuits (including ground wires) with appropriate voltage suppressors at monitoring locations.
- d. In the case if the isolation current/voltage transformers installed at DAU the incoming cables from measuring point should have the insulation level for withstanding high voltage, which can appear on the cable during the switching/lighting surge.

### **High frequency current during the switching/lighting**

In some installation the high frequency current during the switching/lighting can reach level of up to 1000a. In spite of short duration of the current (10-15 microseconds) the circuitry of the sensors connected to the capacitor taps should be design taking into consideration this level of current.