

# Design of a Smart Power Transformer Oil Condition Monitoring & Checking System

Mohammed Sabri A. Raheem

Assist. Prof, College of Electrical & Electronics Techniques  
Foundation of Technical Education, Baghdad, Iraq

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**Abstract:** The main objective of the paper is to design a monitoring system mounted to the transformer tank by which the condition of its oil is checked. Sensors for each elaborated gas is fitted sending those signals, after being processed, to a remotely located control station. Procedures are to be taken to protect the power transformer from being totally damaged due to fault effects occurrence, due to the losing of transformer oil insulating properties because of the thermal effects that leads to the elaboration of gasses. Those effects had to be detected early to minimize the power transformers service outages and increasing the elect. power network system reliability.

**Key Words :** Transformer Oil Tests, Power Transformers , Gas Sensors, PLC.

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## Introduction

Since transformers forms an important section of the electric network, it is of major important to construct protection & control systems that keeps the transformer operated properly. Many protective schemes are constructed to protect the power service from the total break outages[1]. Also the oil condition forms an important factor that keeps the transformer operated properly. Many devices are constructed to test the transformer oil specification and approves the use of the oil in the transformer, but in an off line tests conditions [2]. The faults that occurs in the network, whether total or partial fault affects the chemical composition of the oil & releases gases[3], that will be dissolved in the oil. From the study of the presence of those gases & the ratio of the presence, analysis of the faults that had occurred can be demonstrated, hence knowing the possibility of the loose of the major oil chemical components that are necessary to keep the oil isolates properly. What is performed presently is to take samples of the transformer oil & test the samples in the laboratory to find the ratio of gases that are necessary to discriminate the type of faults occurring & to test the major specifications necessary to decide whether the oil still operative or needs to be changed. These procedures associates for a long time operation & greater probability for transformer damage before discovering the fault occurrence [4]. The present oil gas test methods namely (Dornenberg, Rogers , & IEC 599 ) , gives percentages of perfect gas components ratios of (22.9% , 24.8% & 42.9%), [5] respectively. This means there is a need for developing a more reliable & better operating criterias that sets control & protective systems that eliminates to the minimum the fault effects , especially on transformers. Recently, an operative systems are designed or constructed to demonstrate criteria's that appliessmart techniques to check the oil condition[6].

This paper presents the design criteria's of a monitoring , Testing & protecting system that checks the oil condition & take the decision to protect power transf. from being totally damaged due to the occurrence of partial faults that changes. The oil specifications elaborating gases for each fault leading to loose the basic insulating properties of the oil , hence total damage can happen without being discovered by the presently amounted protective schemes .

## Main System Objectives

1)The main objectives of the Transformer Oil checking system. Basically the oil used in power transformers had specifications that on approval the insulating oil can be used safely in power transformers . The specifications that are standardly assigned to approve the usage of transformer oil in service is shown in table (1) , below : [5]

Still there is a need to check and test samples of the newly shipped transformer oil and tested before installing, also a need for, periodically, test samples of the oil in the transf. tank to detect the faults effects on the oil insulating properties.

**Table (1): Characteristic Data of Power Transformer Oil**

S. No.	Transf. Oil Characteristic	Normal Limit
1	Sludge value	% 120
2	Acidity after oxidation (max) KOH	25 mg
3	Flash point	146.10 C
4	Viscosity at 700 F	37
5	Pour point	-250 F
6	Specific gravity	No Limit
7	Saponification value	1 mg KOH / g
8	Electric strength( 1min)	40

On occurrence of faults inside the transformer tank, gasses will be elaborated due to the rise in oil temperature , that can change , on consequence occurrence the insulating properties of the oil . The type of gasses elaborated & their ratios of existence related to the fault type is shown in table (2) below, [6,7]:

**Table (2): Gasses Elaborated Related To Fault Type**

Fault Type	Primary Gas Component	Secondary Gas Component
Overheating of oil	CH <sub>4</sub> , C <sub>2</sub> H <sub>4</sub>	H <sub>2</sub> , C <sub>2</sub> H <sub>6</sub>
Overheating of oil and paper	CH <sub>4</sub> , C <sub>2</sub> H <sub>4</sub> , CO, CO <sub>2</sub>	H <sub>2</sub> , C <sub>2</sub> H <sub>6</sub>
Partial discharge of paper oil insulation	H <sub>2</sub> , CH <sub>4</sub> , CO	C <sub>2</sub> H <sub>2</sub> , C <sub>2</sub> H <sub>6</sub> , CO <sub>2</sub>
Spark discharge of oil	H <sub>2</sub> , C <sub>2</sub> H <sub>2</sub>	-----
Arc discharge of oil	H <sub>2</sub> , C <sub>2</sub> H <sub>2</sub>	CH <sub>4</sub> , C <sub>2</sub> H <sub>4</sub> , C <sub>2</sub> H <sub>6</sub>
Arc discharge of oil and Paper	H <sub>2</sub> , C <sub>2</sub> H <sub>2</sub> , CO, CO <sub>2</sub>	CH <sub>4</sub> , C <sub>2</sub> H <sub>4</sub> , C <sub>2</sub> H <sub>6</sub>
Dampness or oil bubble	H <sub>2</sub> (Maybe)	-----
Natural ageing	CO, CO <sub>2</sub>	-----

This means that there are main gasses that are elaborated & needs to be fully detected , which are : CH<sub>4</sub> , C<sub>2</sub>H<sub>4</sub> , H<sub>2</sub> , C<sub>2</sub>H<sub>6</sub> , CO , CO<sub>2</sub> , CH<sub>4</sub> C<sub>2</sub>H<sub>2</sub> . To detect those gasses successfully proper sensors are needed and suggested to be mounted inside the transformer tank while the signals collected from the sensors & sent to the control station.

2) The main designed system configurations are :

A)A sensor system , is to be mounted on the transformer tank , that detects the each gas component , shown in table (2), .Gas detectors normally mounted on petrochemical industrialplans & other manufacturing installations ,but in the presented design , the sensors are selected for a specific application. The output signals from each sensor is fed to a control box , locates at the transformer switch yard , collects the signals, processing & transmitting the data to the control station . A block diagram of the control box is shown in figure (1).

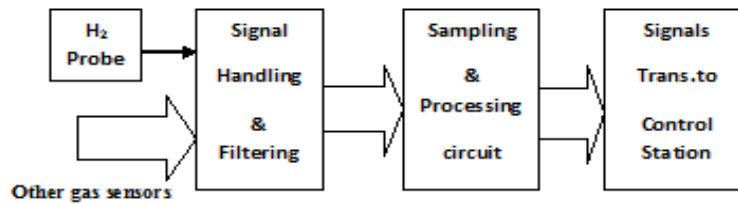


Figure (1) Transformer Side Signal Processing Scheme

B) At the control station terminal the signals from the transformer side are to received , decoded & directed to a plc circuit , where , each parameter must be compared with pre-stored function & a procedure is to be done to explain the transformer oil operating & insulating properties condition. A brief block diagram of the control station block diagram is shown if figure (2) , where the basic functions needed to be installed is given , secondly the proposed signals frame data structure is shown in figure (3) , where the necessary informations needed to install such system is given .

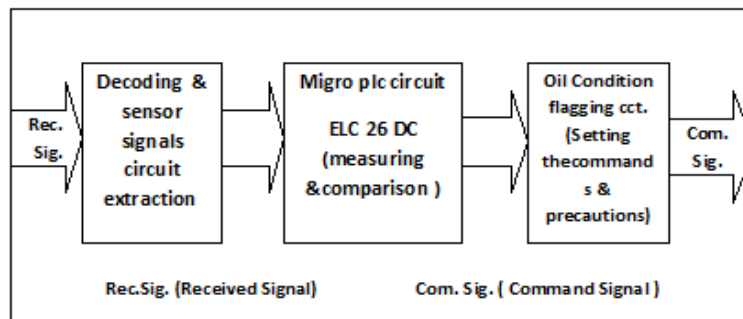


Figure (2) Block Diagram Of The Control Station Side Monitoring System

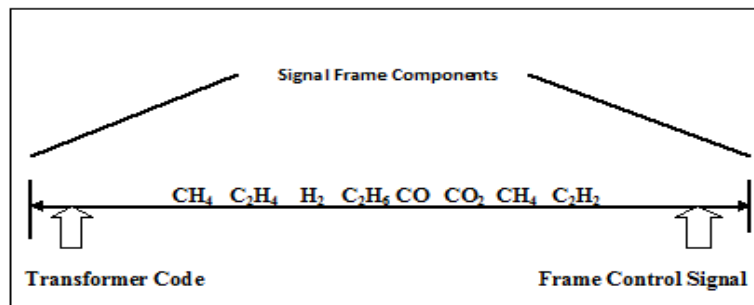
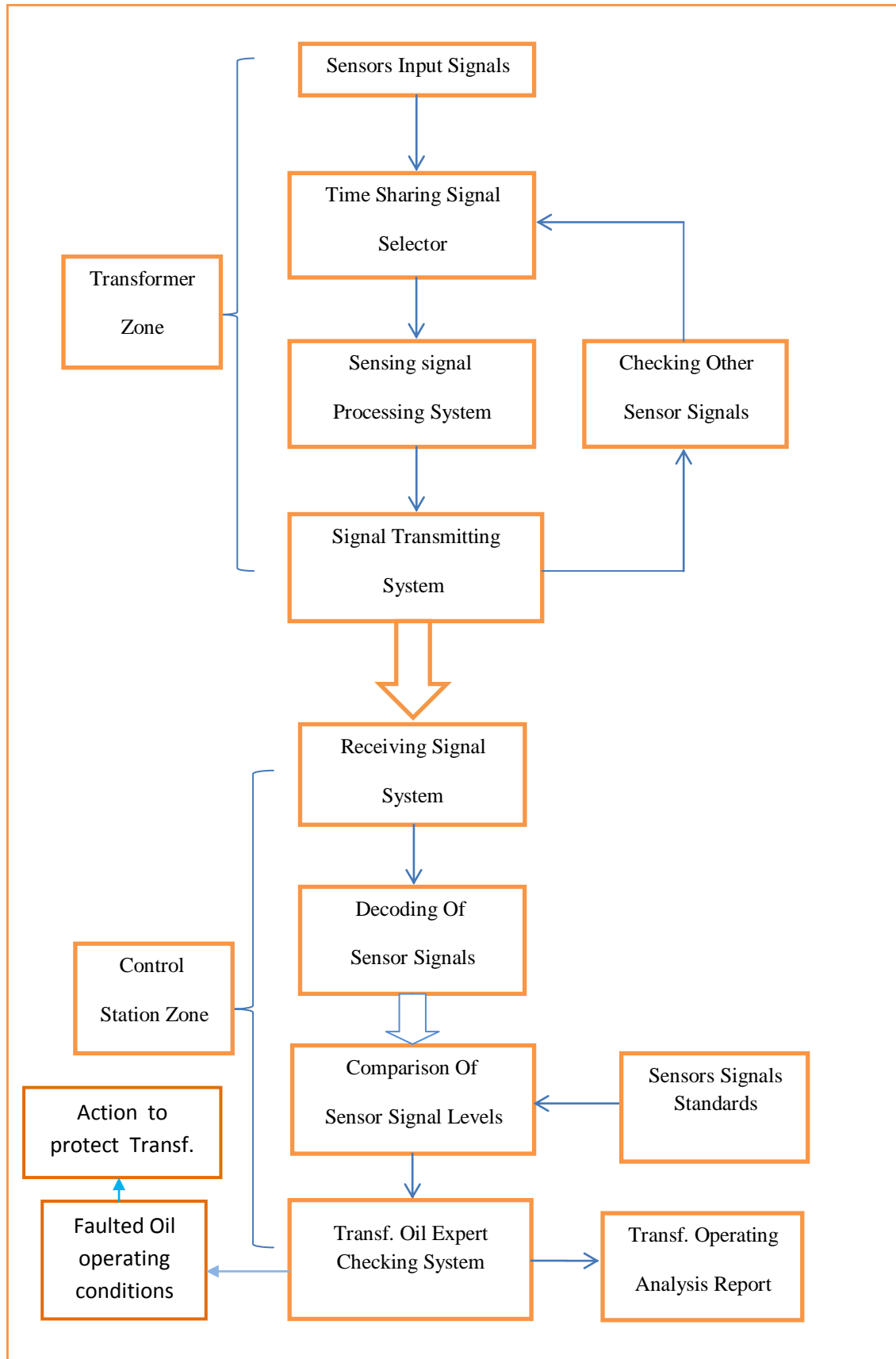


Figure (3) Data Frame Signal Structure

### Designed System Features

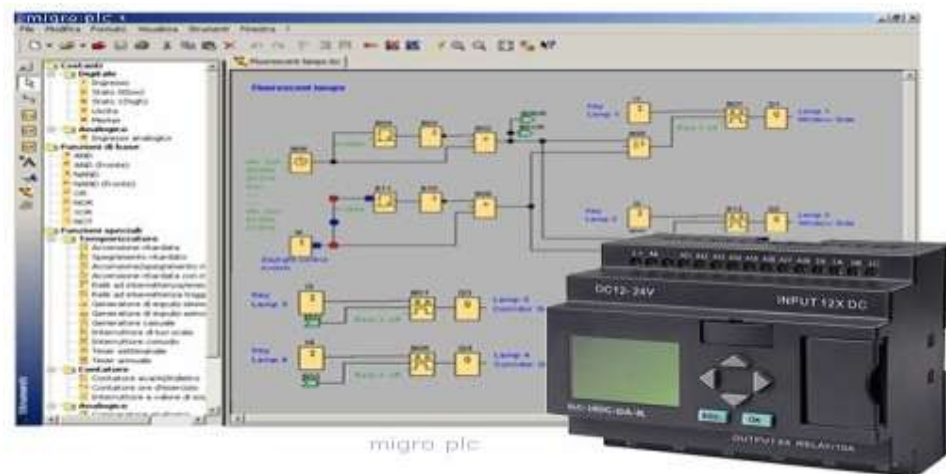
The proposed designed system had some features to be considered on installation and depending on the power network the priority operation of those features had to be set . Those features are briefly :

- 1) The data frame signal structure had been proposed to perform a wireless signal transmission form the transformer switch yard to the control station. Also the a transformer code is set to form an ability to use the circuitry for more than one transformer , while the frame control signal is set to suppress the frames .
- 2) The oil condition analysis is performed remotely in the control station and A real time on-line decisions are made while commands are set to suppress the transformer having oil of bad insulating properties and a flag is set to inform operators to work on and perform maintenance correctly on the transformer.
- 3) The flow diagram of the system operations is given in figure (4) down showing the criteria's of the designed system briefly showing the diagrams of the designed system circuits.



**Figure (4): The Basic Designed System Signal Flow Diagram**

4) The Smart (Expert) System that performs the monitoring & comparison of the oil parameters condition is performed by the (Migro ELC 26) microcontroller whose features& specifications are shown in figure ( 5 )below . [8



Expandable up to 186 I/O  
 Expanded display 4 x 16  
 Support: Modbus RTU/ASCII/TCP  
 Display up to 64 MessagesMigro PLC system  
 Retentive memory on power off features  
 Password protection  
 Optional analog outputs  
 Real time clock (RTC) backup

Figure ( 5 ) Specifications & Features Of Migro PLC

### Conclusion and Recommendations

A smart system , that is used to monitor & detect the insulating properties of the oil used in power transformers by sensing the gases elaborated in the transformer tank , is designed and the main features of the system is discussed. It is recommended by the author to develop the design on implementing the system whether on simulation or real time on line operation of the power network ,since the on line construction of the system persists network problemsforcing to develop some of the design features , i.e: change the wireless transmission data between switchyard & control station to a pilot wire signal transformation .

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