Using Vibration Signal with EHC System to Protect The Steam Turbine from Vibration

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Abstract

This paper will working on the control valve main signal(demand) and the vibration of the steam turbine .will be putting condition to limiting the vibration increase in the turbine and generator, then when resolved the problem caused the turbine or generator vibration the main demand will return to normal value or normal turbine speed . This paper will take the power plant install from the Ansaldo company to work on this type of power plant . In this paper will us three type of circuit,this circuit contain op-amplifier us as comparator and the electronic relay to be isolate the signal in the circuit used and PNP &NPN transistor, by this working can be avoid the damage in turbine or generator result from vibration of the power plant.

Keyword : stream turbine,control system,vibration of steam turbine,turbine protection,steam power plant .

الخلاصة

في هذا البحث سوف نعالج الاشارة الرئسية الخاصة بالصمام الرئيسي مع الاشارة الخاصة بالاهتزاز .سوف نضع شرط لتحديد زيادة الاهتزاز بالتوربا ين االبخاري وكذلك المولد الكهربائي وتحديد السرعة ،وعند ازالة سبب الاهتزاز بالتوربين سوف يزيل هذا التحديد للسرعة. سوف يكون النموذج الخاص بهذا البحث هو منظومة مصنعة من قبل شركة انسالدوا الايطالية المستخدمة في المحطات .سوف نستخدم ثلاث انواع من الدوائر الاكترونية تحتوي على مكبر اشارة وكذلك صمام ترانستور من NPNو PNP،
باستخدام هذه الاشارة سوفه نتجنب حدوث ضرر بالتوربا ين نتيجة ارتفاع الاهتزاز في المحطات الكهربائية .

الكلمات المفتاحية،التوربينات ونظام التحكم، والاهتزاز من التوربينات البخارية، التوربينات الحماية، ومحطة الطاقة البخارية.

Introduction

Damage of steam turbine blades has always resulted in great economic losses.It is very expensive to open a turbine,dismount casing and stationary blades,remove rotors and replace damaged blades, to install diagnostic systems and operate turbines,so that early detection of blade damage would prevent extensive accidents(Procházka andF.Vaněk,2011).

Several present day problems requiring attention by designers, and solution by researchers For every blade which cracks or fails during operation there are two questions which should be asked, 1) what caused the failure to occur, and 2) what modifications are needed to prevent failure in the future? Experience has indicated that if 1) is neglected, then the fix in 2) has a 40% chance of failing again **(**Rieger and Nowak, 1977), Rub between tip seal components or gland seal components,,,, reason, rotor bowing due to thermal bending and/or residual unbalance. ,(Neville , 2002). During a plant's lifetime, I&C systems must be replaced at least once due to I&C equipment obsolescence. An average plant life span is 40–60 years, whereas an average I&C equipment life span is 20 years. As of 2009, about 358 plants exceeded their operation ages by 20 years (IAEA, 2010). The I&C upgrade is distinguished into intentions such as a prompt upgrade and planned upgrade. A prompt upgrade occurs only when I&C equipment faces an operating problem, which is a general practice occurring in the existing plants. A planned upgrade occurs with a long-term plan in mind. The I&C systems surely have the obsolescence problem after 20 years since its first operation. With this in mind, this upgrade is usually hard to succeed because it demands several changes in the plan, during the upgrade, due to unexpected events caused by financial, technical, and environmental conditions(Yong *et al.,* 2011).

Differing mechanisms have hitherto been presented to compensate for the control valve nonlinearity characteristic. A proportional linear operation was obtained by a mechanical hydraulic control (MHC) using cams. In this method, MHC improved the system by producing a nonlinear electric compensation to the nonlinear system of control valves. A different compensation approach was proposed by adopting the electro hydraulic control (EHC) using electrical “cams” instead of mechanical cams (Eggenberger, *et al.,* 1963) Generally, the EHC systems provide more flexibility than the MHC systems for power plant turbines (EPRI, 2006) Steam turbine control valves play a pivotal role in regulating the output power of the turbine in a commercial power plant. They thus have to be operated linearly to be run by an automatic control system .(Halimia & Kune , 2012)

3- Electro Hydraulic Control (EHC) system

EHC is (electro hydraulic control)The old analog system controls the Parsons steam turbine, interfaces with the Main Steam valves and controls the turbine speed and load, analog equipment limping along as best the I&C technicians can keep it running. When it comes to the end of a piece of I&C equipment’s advanced age :

- the equipment fails with no hope of revival,
- a replacement part is found not to exist,
- the equipment is termed obsolete, and
- a replacement must be found.(Steven& Samir ,2009)

3-1 Structure of EHC

As shown in Fig. 1, an EHC is composed of six subsystems, such as the main steam pressure control subsystem, the turbine rotation speed control subsystem, the turbine load control subsystem, the turbine load limitation subsystem, the bypass control subsystem and
the automatic turbine load following subsystem. Its input signals are the main steam pressure Pmsps, the turbine speed vtur and the turbine load L, while the output signals are the CV steam flow rate wcv, the IV steam flow rate wiv and the BPV steam flow rate wbpv (Qiao *et al.,* 2004).

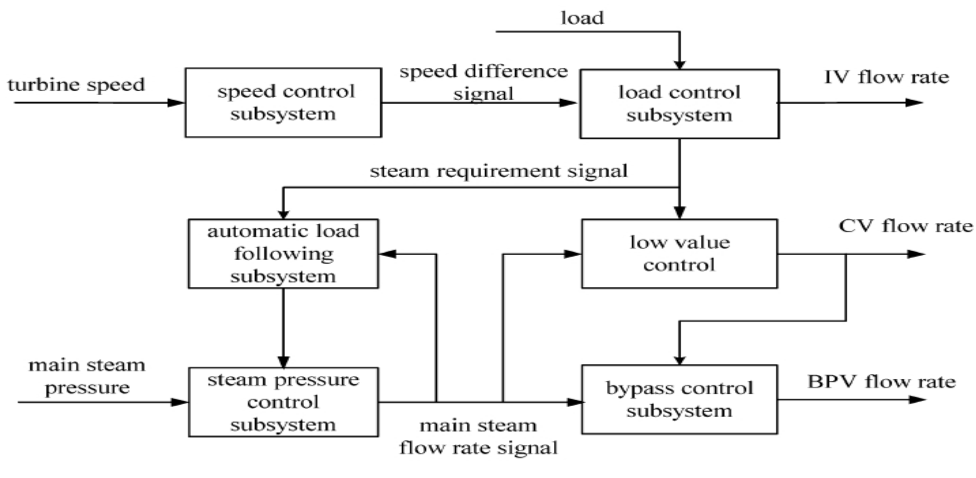


Fig. 1 Conceptual structure of EHC [Steven& Samir ,2009]

3- 2 Definition of functions in power plant :-

defining primitive functions of I&C systems as follows:

–Instrumentation functions:-acquiring process signals from the plant and sending them to other systems.

–Protection functions:- actuating safety components for tripping the plant when detecting abnormal conditions of the plant.

–**Control functions:-**controlling the plant both automatically and manually.
– Monitoring functions:- for the operators to monitor the plant's state.
–**Alarm functions:-** alerting the operators before the plant becomes an emergency state.
–**Independent functions:-**such as a radiation, seismic and vibration monitoring system, turbine control and monitoring system.
–**Analog backup functions :-** actuating only when the digital functions are inoperable.
(Yong *et al.,* 2011)

4- Related works :-

A partial active control of torsional vibration on turbo-generator has been adopted in the (Hao, &Elliott, 1996; Hao zhiyong & Gao Wenzhi, 2004) and effective reduction of torsional vibration at some position of shaft has been obtained. But neither the control force nor the torsional vibration energy attenuation of the rotor shaft is optimum.
Despite the fact that there are some measures on the passive and active control of the turbo-generator rotor shaft, so far the measures reducing the torsional vibration of the turbo-generator have not been quite effective. The focus of this work shall be on the active control strategy of torsional vibration of rotor shaft on large turbo-generator. A theoretical study and simulation test on the active vibration control scheme for controlling torsional vibration of a rotor shaft of turbo-generator are conducted as shown in fig-2- . (Wenzhi & Zhiyong, 2010)

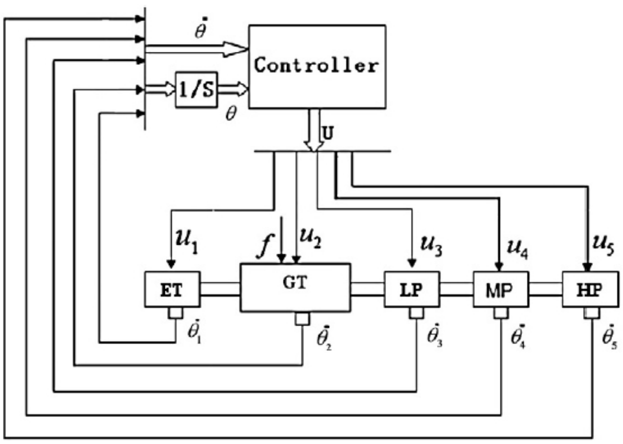


Fig.- 2- simplified and control block diagram[Wenzhi & Zhiyong, 2010]

5- Design and simulation of protection circuit :-

In this work will use (5spice Analysis) program to simulation output of the circuit No. 1,2,3. Steam Turbine control system in power plant depended in main working to controlling demand of the control valve, the control valve(C.V.) (open &close)depending on the many signal input to EHC as (speed, vacuum, load and main steam pressure) all these signal will result one main signal(main demand) , the main signal of CV will add to the output signal from the vibration circuit shown in fig (3) , to limit the speed if the steam turbine have vibration over the limit value .When the turbine have high value from vibration will appear voltage output from circuit No.3 this voltage will add as negative voltage with main demand of control valve then will reduce the demand voltage and decrease the open of C.V. result to reduce the speed of the steam turbine to be in safety side from vibration value .If the vibration will continuous increase in turbine this will increase value output signal from circuit No.2 and will decrease open the C.V. to decrease turbine speed to reach to the zero speed.

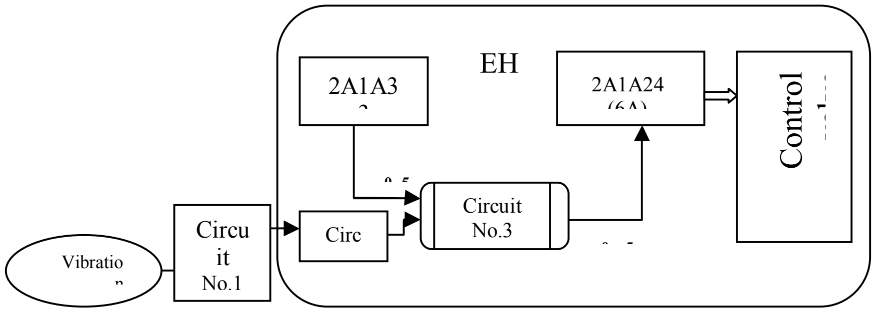


Fig- 3 - signal flowchart from vibration circuit and main signal in EHC

flow chart of this work shown in fig -5 represent the all work , each vibration output voltage will be input to circuit No. 1 and each two output from two circuits No.1 will be input to one circuit No.2, to compare and give the bigger valve from the two input vibration voltage ,

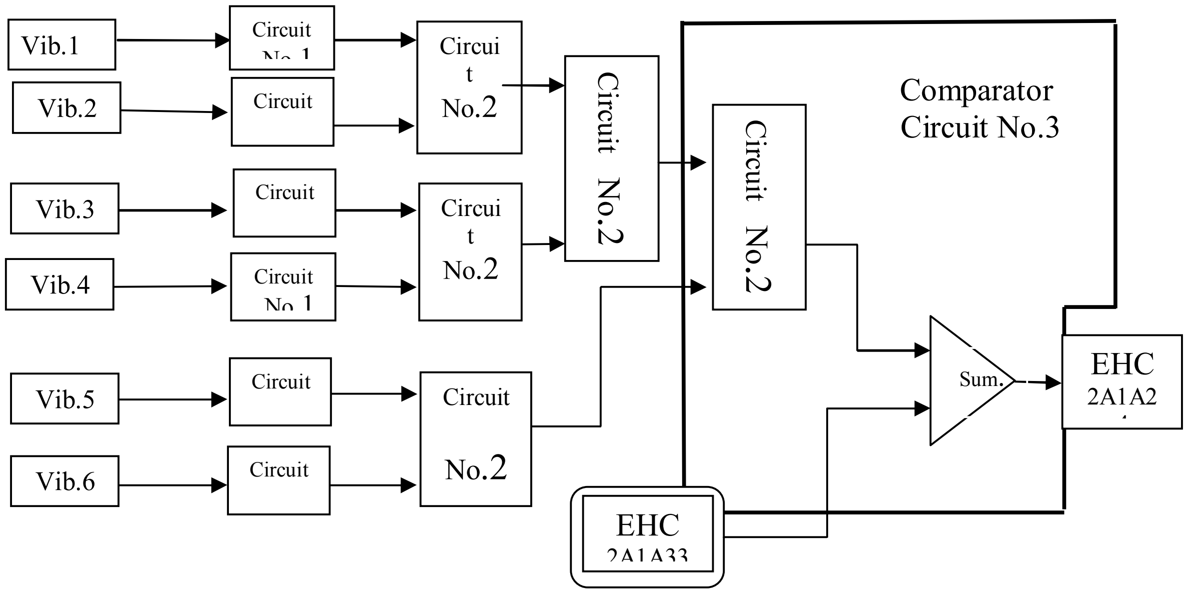


Fig-4- work of all vibration channel with EHC system

by using multistage from circuit No.2 the end will take or see the bigger signal value from six vibration value to be input to the op-amp in circuit No.3 with the main signal of the EHC demand, and result new mixed signal ,to be new main signal(new demand) to control valve.

5-1 Operational amplifiers:-

An operation amplifier , or op-amp is very high gain amplifier with high input impedance and low O/P impedance , typical uses of the operational amplifier are to provide voltage , and many types of instrumentation circuit .Action resulting when two separate signals are applied to the inputs of op-amp. The O/P will be difference signal being $V_d = (V_{i1} - V_{i2})$ shown in fig (5)

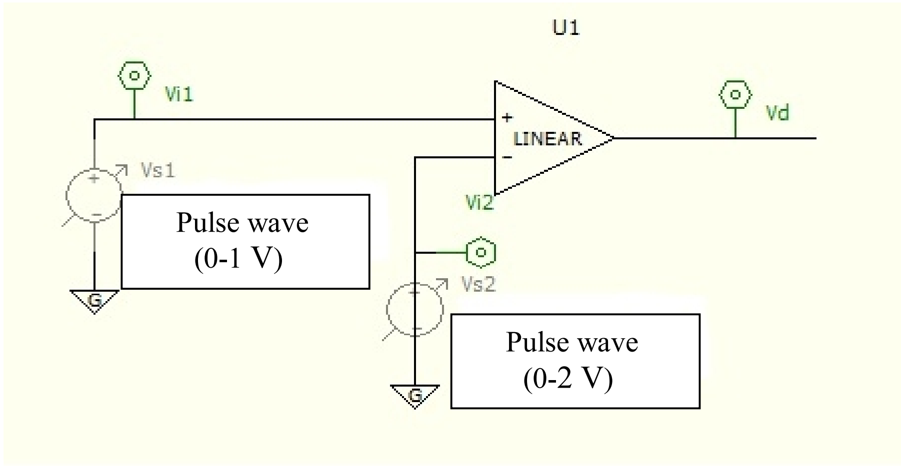


Fig -5- Op-Amplifier work as comparator

Operation amp. Can be used to drive a lamp display and device ,the O/P at terminal goes to positive saturation level , (Robert L. Boylestad &Louis Nashelsky, 2007)

5-2 Work and discusses of Circuit No.1 :-

This circuit shown in the fig-6- the inputs to this circuit will be signal DC voltage from vibration sensor card it value shown in table No.1 and the other input signal will be reference voltage we can change the reference voltage , any voltage come from vibration over the reference voltage to this circuit, output will be the **difference** between these two signal .The output value will be zero if the vibration signal lower than reference voltage because we use only one output from (Vsw3), the Q2 transistor is controller the switch(Vsw3), the U1 is controller to the Q2 transistor . The output of this circuit will be input to the circuit No2.

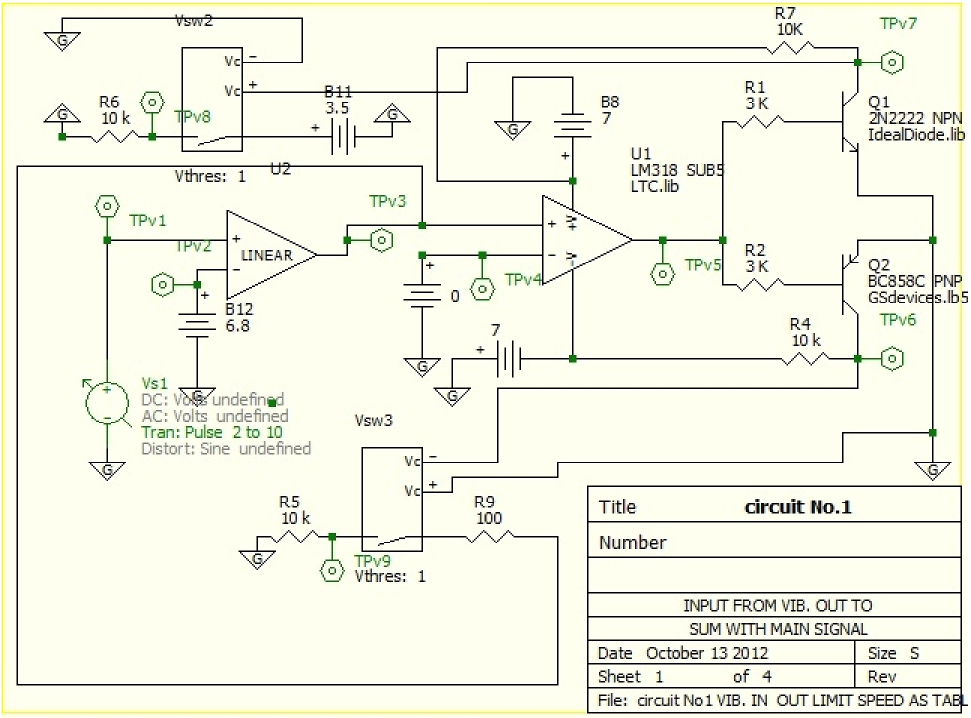
The op-amp switching circuit is the op-amp comparator of this circuit, you will note, does not employ feedback. As a consequence of this,

$$Vd = AV\ (Vi1 - V_{i2})\ldots\ldots\ldots\ldots(1)$$

Because of the large gain that characterizes the open-loop performance of the op-amp (AV (OL) > 10^5), any small difference between input voltages, will cause

large outputs, simple modification of the comparator circuit just described consists of connecting a fixed reference voltage to one of the input terminals; the effect of the reference voltage is to raise or lower the voltage level at which the comparator will switch from one extreme to the other (Rizzoni, Principles and Applications of Electrical Engineering 3rd ed. , 2001).

(fig. 7) input to linear operation amplifier U2 from vibration signal and the reference signal ,the O/P of this op-amp will be I/P to the U1 .Output of U1 will be (+5 V) if the vibration signal lower than reference voltage , and will be (-5 v) if the reference voltage lower than vibration voltage , than Q2 will be operate if vibration lower than reference and result to work VSW1 to give the difference value between two these signal as in (fig. 8)



(Fig-6) circuit No.1 connect with vibration sensor

(Table -1) –the decrease ratio with output of the vibration circuit

Vibration ratio		Voltage O/P(2-10V)	decrease value from demand
1	50%	6 V	X
2	60%	6.8 V	X
3	70%	7.6 V	0.8 V
4	80%	8.4 V	1.6 V
5	90%	9.2 V	2.2 V
6	100%	10 V	Turbine trip

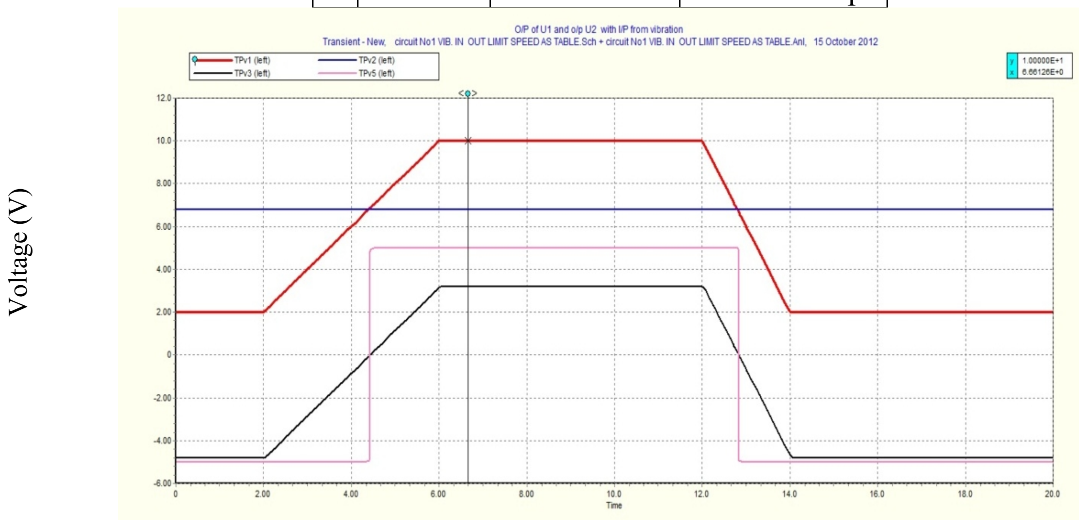


Fig- 7- input of circuit 1 with the output of U1 and U2

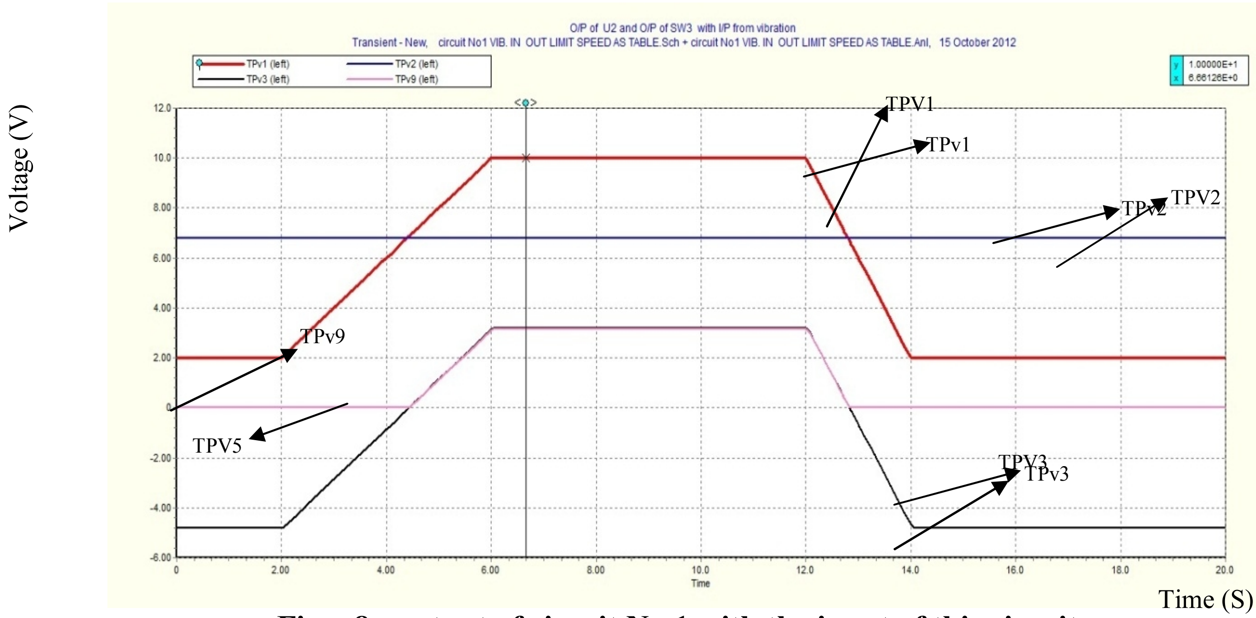


Fig – 8- output of circuit No.1 with the input of this circuit

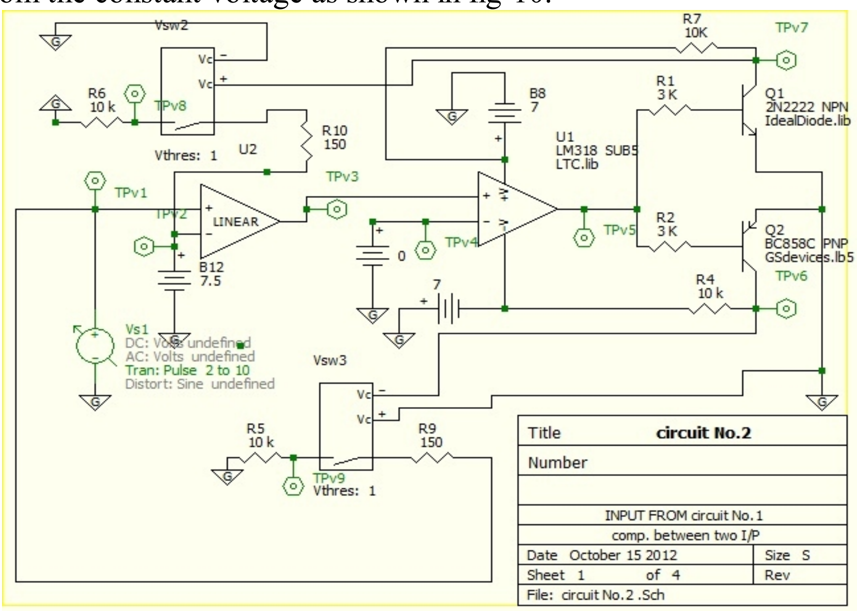
5-3 Work and discusses of Circuit No.2:-

Time (S)

This circuit shown in fig. 9 working of this circuit and component sam as the circuit No.1 , but in this circuit we have two input to the U2 come from the two output of the circuit No.1 as shown in flow chart and one output represent the bigger value from the two input voltage , the work of the type is to compare between two input voltage and the output will be the bigger value from the input values. by us multistage from this cuircuit as shown in flow chart to this work find the bigger vibration value result from the steam turbine vibration sensor .

To simulation work to this case will use two input voltage (constant d. c. voltage and input pulse voltage change with time).

In TP1 &TP2as shown in the fig -10,the output will be find in TP8 when the constant voltage bigger from the pulse voltage, and will find in TP9(Vsw3) when the pulse signal is bigger from the constant voltage as shown in fig-10.



(Fig-9) circuit No.2 compare between two output of circuits No.1

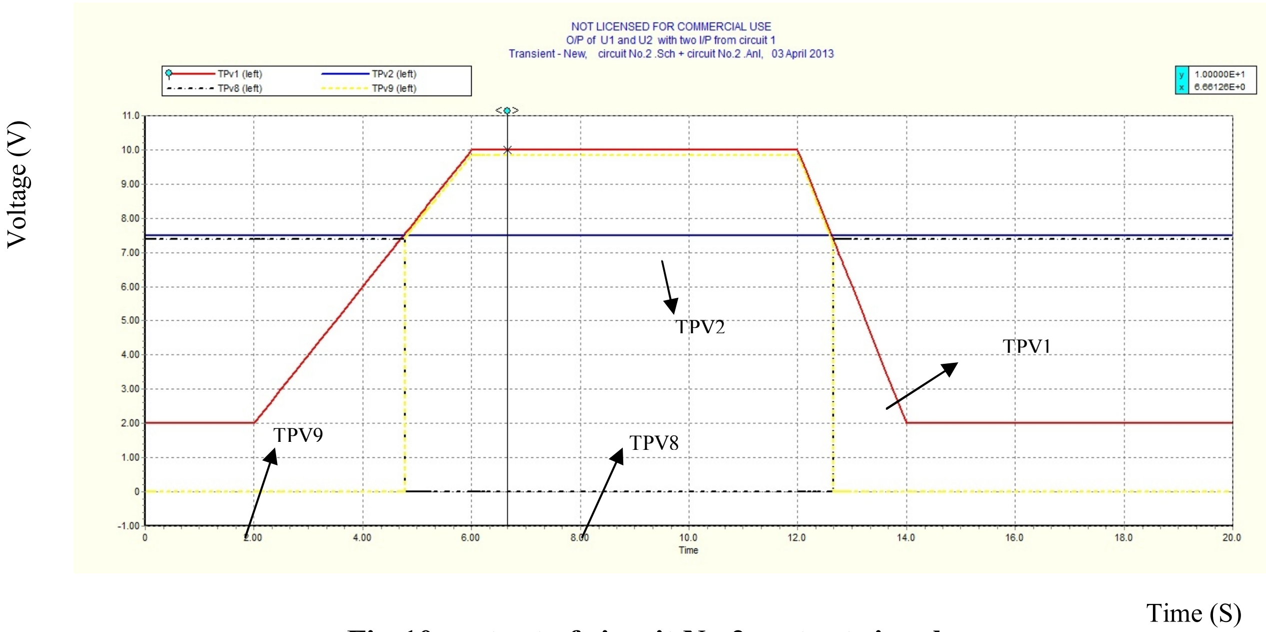


Fig-10- output of circuit No.2 ,output signal from Vsw2 and Vsw3

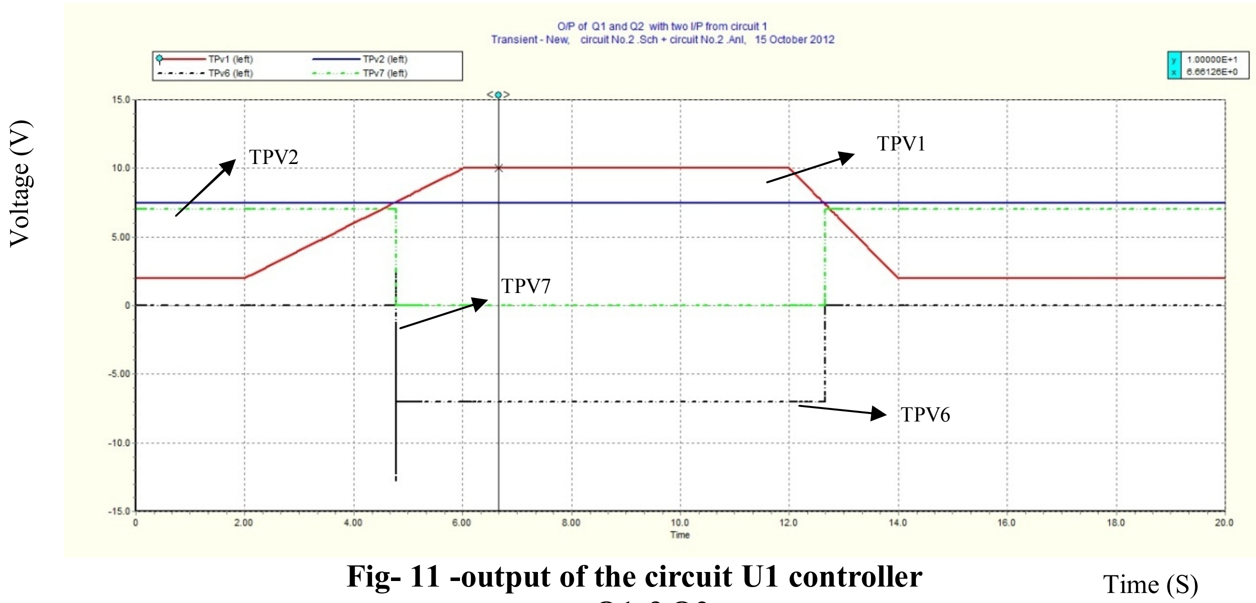


Fig- 11 -output of the circuit U1 controller to Q1 &Q2

The output can provide a voltage at one of two distinct levels or can be used to drive a lamp or a relay .notice that the output is taken from a bipolar transistor to allow driving a variety[13] .The Q1&Q2 working in this circuit same as circuit No.1 the op-amp. U1 is Controller the Q1&Q2 ,the Q1 will be in off case when the Q2 is operation , and the Q2 will be in off case when the Q1 is operation depending on the input value of the circuit as shown in fig-11.

In fig -12 shown the logic output of U1and output of U2 with two input signal chang with time in the circuit No.2

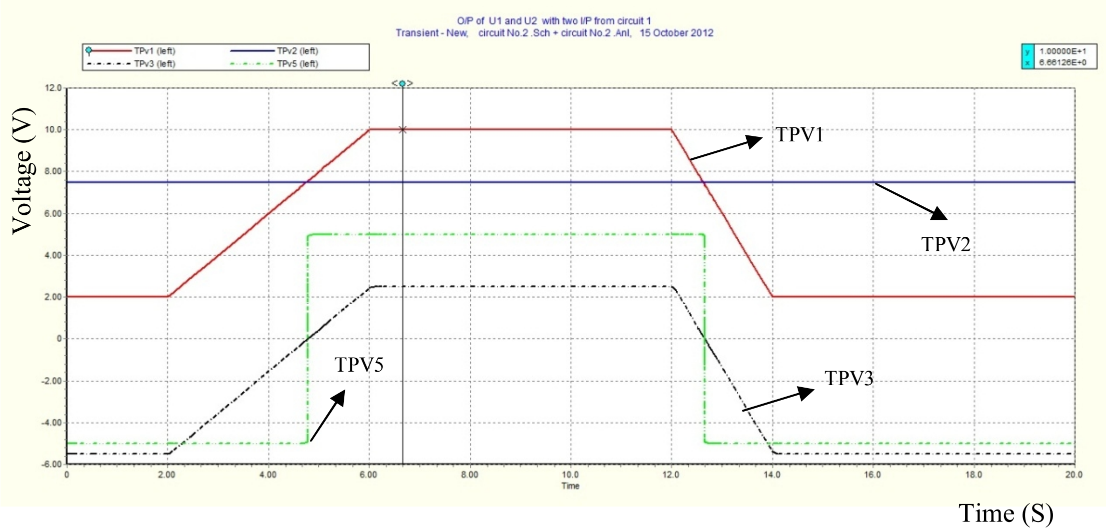


Fig- 12 - circuit No. 2 output of U1 & U2

5-4 Work and discusses of Circuit No.3:-

This circuit is shown in fig -13, same as the circuit No.2 but will add to this circuit new op-amp. U3, by this op-amp will add the vibration voltage gate it from circuit No.2 and the main signal of the steam turbine the result from this op-amp will be new main signal us to controller the turbine. The new main signal will be same as the main signal in value if the steam turbine do not have vibration value over my reference . And will decrease from the main signal if the turbine have vibration value over my reference, then will reduce the speed of steam turbine by increase the closed of the control valve to be in safety side from the vibration . If the vibration will continuous to increase this will relate to be shut down to the turbine, this working shown in fig-14.

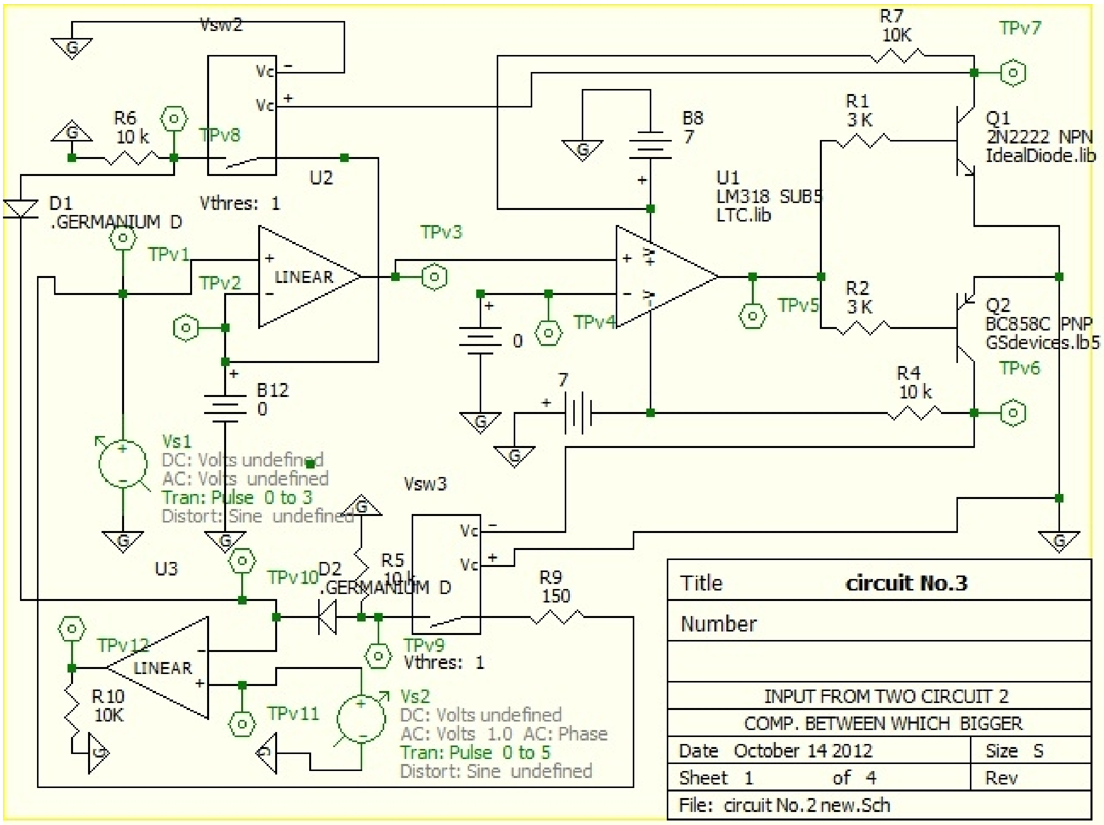


Fig-13 circuit No.3 add the output from circuit No. 2 with valve controller signal

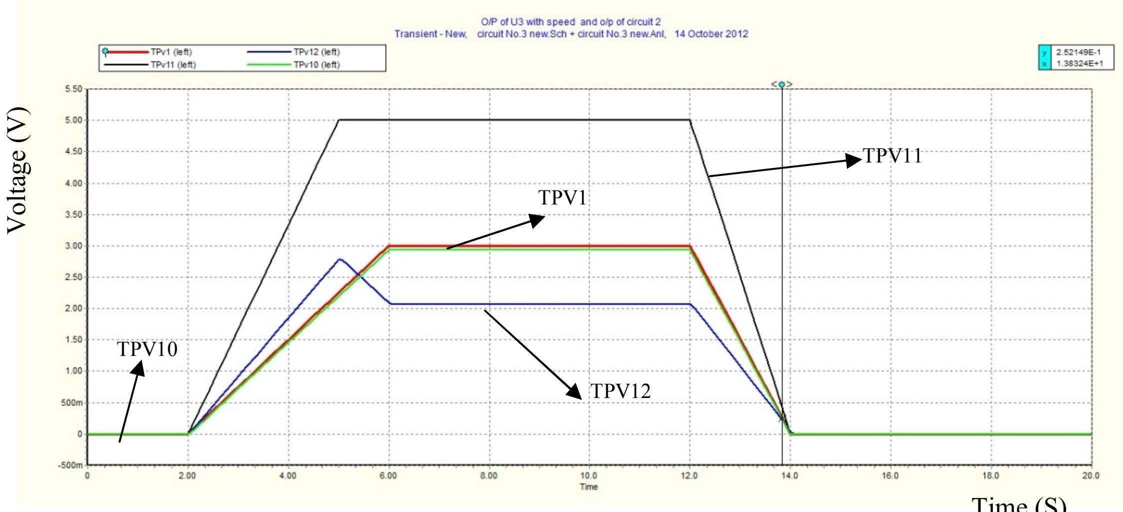


Fig-14 output of circuit No.3

Conclusion:-

In this paper we mix turbine main demand signal with vibration signal by add new condition to limit the increment value of speed turbine , by this new signal product we can decrease the turbine speed when vibration increase automatically, the new demand will increase protection to turbine . I used (5spice analysis) simulate program to complete this investigation .

The result of this simulation are good response when increase the vibration in anyone from six channel vibration will decrease main demand signal of the turbine , and than will decrease turbine speed to product it from this value of the vibration . By using circuit No.1 we can change the limit value of the vibration to any new work or to other kind from steam turbine .

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