SAFE LOGIC, TRIP PERMISSIVES AND STEAM TURBINE PROTECTIONS

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Abstract
In a complex system of machinery there are numerous components which work together in a definite fashion to achieve ultimately process control .However some time due to error or malfunctioning of instrument the parameters which are essential for the process to continue gets deviated from the normal range. At such times a proper logic flow becomes very essential from safety point of view. An uncontrolled deviation may cause significant economical, environmental and human life loss. The article discuss about some of the many aspects of logical permissives and safety inclusions which helps to provide annunciation to the operator and may even abort the process after certain programmed time interval if not acted upon.
Index Terms:Interlock, Permissives, PLC ,Tripping ,Turbine protection

I. INTRODUCTION

Power plants rely on a sophisticated network of instruments each having specific functions, every instrument has their own control mechanism [7]. In a power plant having steam turbine numerous factors such as boiler, fuel handling, temperature and pressure sensors , control valves play important role in electricity generation process. To allow proper functioning of the system it is necessary that they should be regulated and their parameters should be looked into real time [3]. Generally these elements are governed by a Programmable Logic Controller (PLC) which should be appropriately programmed to maintain synchronization amongst the instruments.

The Turbine Protection System (TPS) provides an additional independent protection function for the steam turbine and generator. The TPS detects undesirable operating conditions and initiates trips to avoid damaging the steam turbine [4]. Besides establishing control it is very important to ensure that all instruments are failure free. Permissives , sequence , trip are logic instructions needed to ensure overall safe operating procedure [6]. While designing a particular sequence of actions all the factors should be considered such as normal operating environment and various possible failures that may occur [1]. The system should be able to handle all abnormalities and undergo proper shutdown if needed.

The function of the steam turbine protection system is often confused with the control system, but the two systems are entirely separate [9]. The protection system operates only when any of the control system set point parameters are exceeded, and the steam turbine will be damaged if it continues to operate [8]. A multi-valve, multi-stage turbine protection system incorporates a mechanical overspeed device (trip pin) to shut down the turbine on overspeed (10 percent above maximum continuous speed)[2].

II. TRIP, PERMISSIVES AND SEQUENCE

Tripping is an action that is initiated by the control system and which forces a single or multiple devices into a safe or pre determined state .The safety instrument system generally initiate trips , however Programmable logic controller (PLC) may also initiate trip provided they are feed with the necessary logic and receive sets of inputs from the instrument they are suppose to govern .Once a device or devices have been forced to a predetermined state by the action of Trip they will remain in that state till the Trip is manually acknowledged or the problem has been rectified by human interference .

An interlock is a self resetting trip. Interlocks are not deemed safety related and can be used for on/off control. Interlocks are normally initiated by the PLC, but if an interlock is deemed to be safety related it may be implemented in the SIS or a hardwire system .An interlock forces a device to a pre determined state .Once a device has been brought to a pre determined state by the action of an interlock they remain in that state until the cause of the fault returns to healthy state, the interlock will then automatically be removed .It is possible to override the interlock.

A permissive is a particular type of interlock that is used to prevent actions taking place until pre determined criteria is satisfied. Ex : Preventing pump from starting until the valve is open .Permissives are normally initiated by the Programmable Logic Controller , however if a permissive is deemed to be safety related it can be implemented in SIS or hardwire system .After the permissive has been satisfied and the corresponding action is taken , it becomes inactive .For example once the suction valve has been opened and the pump started the permissive takes no further action , even if the suction valve is the suction valve is closed while the pump is running .It is possible to override permissives for operational or maintenance reasons.

A sequence is a pre arranged action or a set of multiple actions which are carried out by the control system. They can be initiated by event or by the operator .Alternatively PLCs can also be programmed to carry out the set of instructions required .This helps to reduce human intervention significantly .Sequences can be single pass or cyclic. Following are examples of sequences for maintaining vessel level.

A. Single pass

A vessel reaches pre determined level. The following sequence is carried out :

1. Stop the feed pump
2. Close the filling valve
3. Stop agitator
4. Wait for 60 seconds or as specified
5. Open discharge valve

B. Cyclic sequence

1. Low level in a vessel opens the filling valve
2. The valve remains open until high level is detected
3. On high level the valve closes
4. The valve remains closed until low level is detected
5. On low level the valve opens and the sequence is repeated

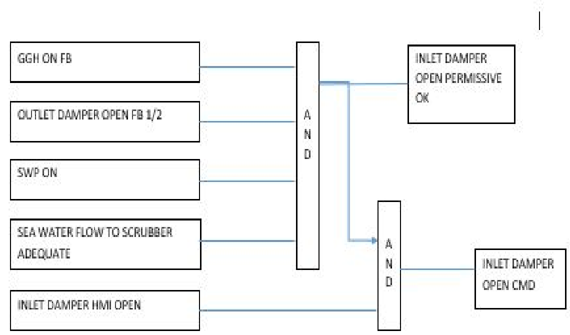

Fig 1. Feed Water Pump protection logic

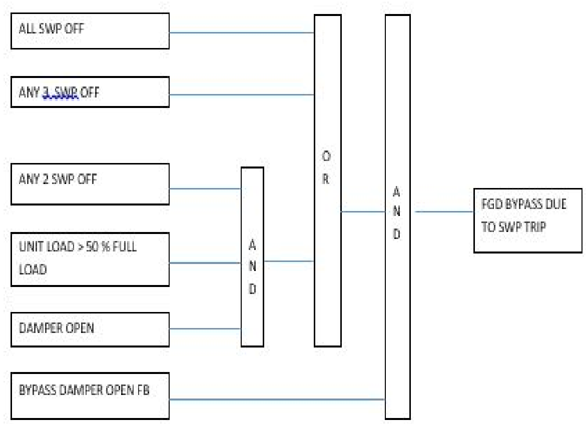

Fig 2. FGD bypass system logic

III. TURBINE PROTECTIONS

Turbine protections are essential part of the turbine system. Turbine is a heavy mass running continuously at around 3000 rpm. It handles high pressure & temperature. There is very less clearances between rotating and stationary parts. It is very important to protect turbine during emergencies in the grid. Over speeding of turbine needs to be avoided in any case.

The turbine Protection System can be actuated by any of the following trip system:-

1. Hydraulic Trip System
2. Electrical Trip System

Both the trip system when initiated act on the hydraulic control system and cause trip oil to drain which in turn closes the emergency stop valves & control valves.

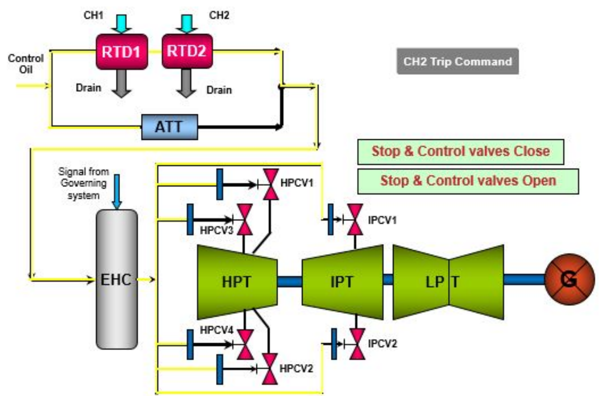

Fig 3. Turbine Layout

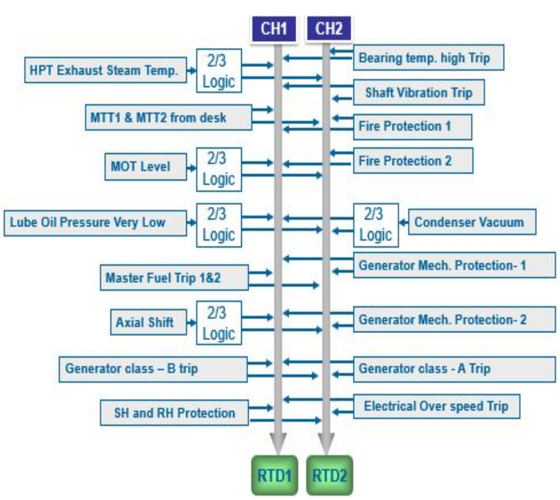

Fig 4. Annunciation taken from RTD

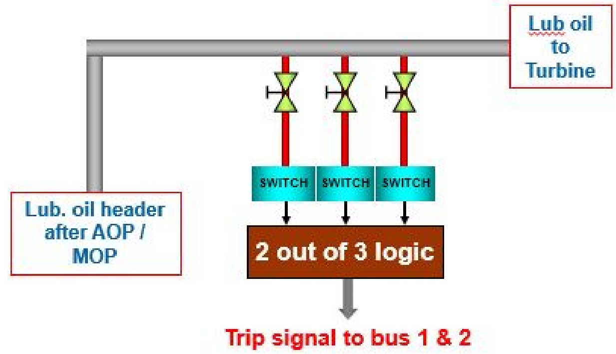

Fig 5. Lubrication Oil system protection

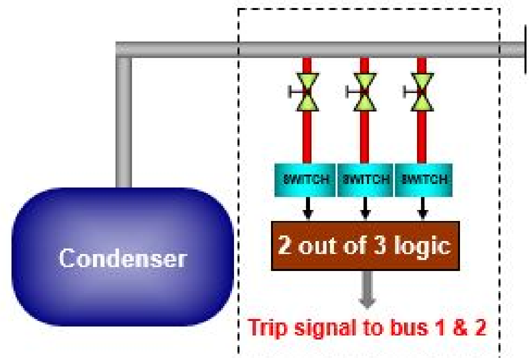

Fig 6. Condenser system

Over speed Electrical Trip: Turbine trip signal will be initiated by DDC if Turbine speed crosses 3200 rpm .This parameter can be called Over speed turbine 1 or OST1 . OST2 can act as a backup protection for OST1.

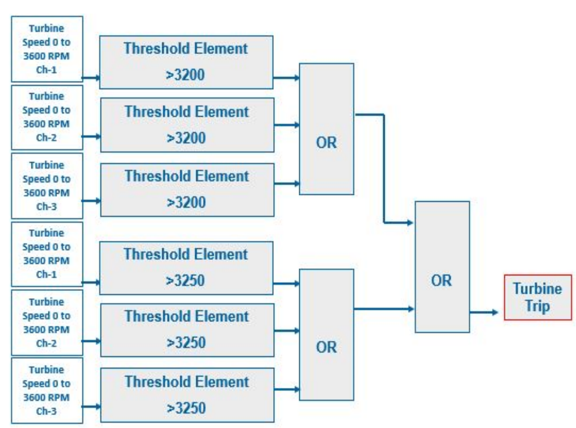

Fig 7. Logic for speed parameters

Turbine trip protection is provided on 320 Micron shaft vibrations by ANDing both X and Y direction shaft vibration with a delay of 5 sec.

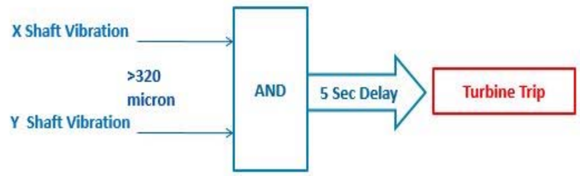

Fig 8. Logic for Vibration parameters

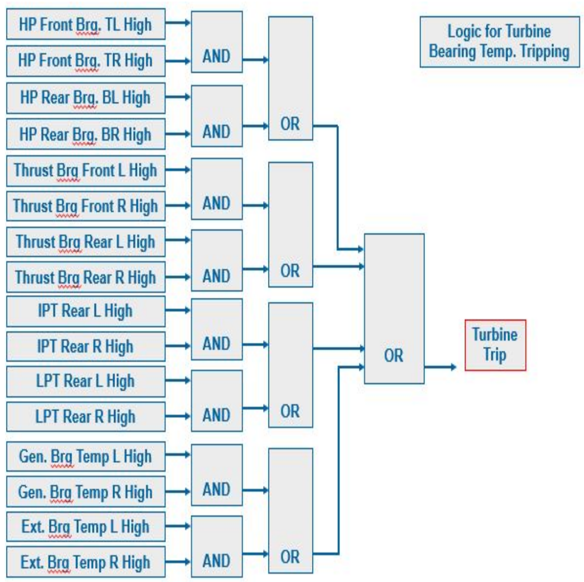

Fig 9. Logic for Bearing Temperature parameters

Following is a sample oil tank holding lubrication oils. Supposing the height of the tank to be 1500 mm. The level transmitter extends throughout 1500 mm length. Three indications namely Adequate, Low and Very Low are taken from the vessel. Very Low indication is critical parameter and may cause the turbine to trip. To increase the reliability of the logic and to avoid false alarm a 2 by 3 logic is provided, 2 by 3 logic is most common logic protection for all critical readings. Satisfying 2 out of 3 logic initiates necessary annunciation and tripping. It is rightly called as 'Trip Logic'.

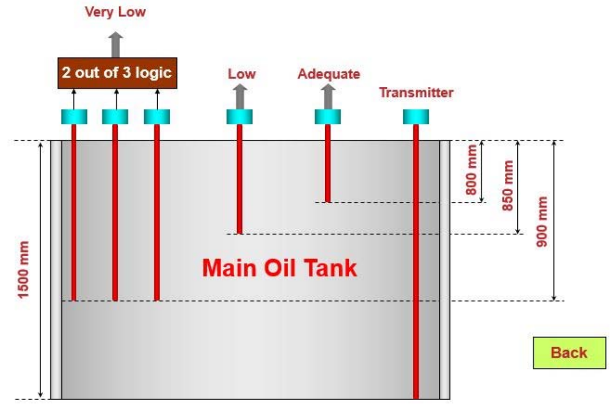

Fig 10. Tank level indications

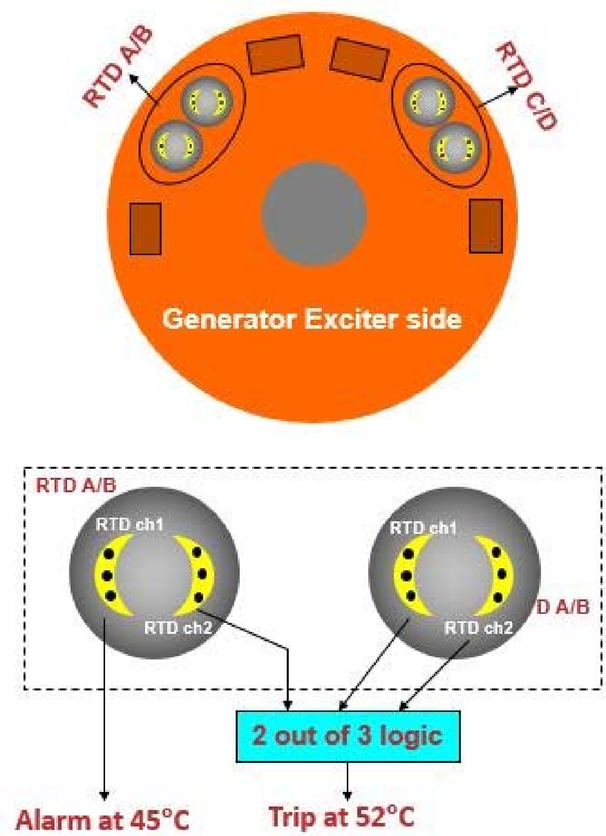

Fig 11. Generator Tripping and Alarms

Generator consists of Resistance Temperature Detectors (RTDs) embedded in the core structure of stator and rotor itself. The 4-20 mA general output from these RTDs are taken and passed through 2 out 3 logic which in this case will give an alarm when output current corresponding to 45 ^{0}C is obtained and will trip the generator at 52 ^{0}C in this case. 2 out of 3 logic requires output from 3 separate channels of RTD.

Table 1. Sample parameter deviations and their response

Sr No	Description	Values		
		Normal	Alarm	Trip
1	Fire Protection	-	-	Trip
2	Emergency Trip Push Button	-	-	Trip
3	Shaft Vibration (Microns)	<45	120	>320
4	MOT oil level (from top) 2/3 logic	800	850	900
5	Over speed Trip	-	-	110%
6	Axial Shift very high +/-	−0.3 mm	±0.5 mm	±1 mm

IV. CONCLUSION

By passing the required input parameters through proper sequence of AND, OR gates annunciation can be acquired when necessary. Additionally by providing a time delay we can allow human interaction before the system tripping takes place.

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