PALO VERDE
NUCLEAR GENERATING STATION

I&C Program

Classroom Lesson

I&C Program	**Date: 7/16/2010 8:39:54 AM**
LP Number: NID16L000203	**Rev Author: DANIEL R. REED**
Title: Safety Channel Excore	**Technical Review:** Jones, Warren H(Z54741) Digitally signed by Jones, Warren H (Z54741) DN: cn=Jones, Warren H(Z54741) Reason: I have reviewed this document Date: 2010.07.16 11:06:03 -07'00'
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INITIATING DOCUMENTS

Site Maintenance Training Program Description

REQUIRED TOPICS

None

CONTENT REFERENCES

LER 88-012-00 Channel 'D' Linear Power Inoperable

LER 89-010-00 Reactor Trip due to erroneous power signal

TCS 92-1533 CRDR 12-0376 Excore Log Calibrate Switch Replaced

TCS 92-1890 CRDR 12-0018 Log Channel 'C' failed low

TCS 93-1556 SER93-13 Operation with reversed excore detector input signals

TCS 96-0631 Significant Event Notification 136 " Recurring Events"

TCS 96-0717 CRDR 96-0127 Uncertainties of High Log Power Trip Setpoint

TCS 97-1927 Reactivity Management

TCS 98-1434 First Quarter Interface Meeting Notes

TCS93-1847 SER93-08 Incorrectly adjusted Scram Setpoints

TCS97-2418 Excore Signal Attenuations (White Paper)

VTM-C490-0002 Excore Neutron Flux Monitoring System

TCS 3225113 CRDR 3214384 Incorrect Bypass Switch Operated during performance of Log Channel Excore Functional

LESSON PLAN REVISION DATA

Jul 16, 2010 Dan Reed 01 Added TCS 3225113 course material

Tasks and Topics Covered

The following tasks are covered in Safety Channel Excore:

Task or Topic Number*	**Task Statement**
Lesson:	Safety Channel Excore
SE11	Perform "Log Power Functional Test", 36ST-9SE06 or equivalent
SE07	Perform "Excore Linear Monthly Calibration", 36ST-9SE02 or equivalent
SE12	Troubleshoot excore safety channel

Total task or topics: 3

TERMINAL OBJECTIVE:

1 Given the appropriate reference material and the necessary test equipment, the I&C Technician will, troubleshoot and maintain the Safety Range Excore System. Mastery will be demonstrated by successfully completing a lab practical evaluation.

1.1 Describe the function and operation of the major circuits utilized in the Safety Range Excore System, including inputs and outputs and discuss Prevent Event Tools and Electrical Safe Work Practices that can be use to minimize human performance errors.

1.2 Describe the function and purpose of all front panel indications and controls on an Excore Safety Channel Drawer.

1.3 State the conditions which will cause a trip signal to be generated in the Plant Protection System from the Safety Channel Drawer.

1.4 Describe how unwanted trips in the Plant Protection System are prevented while performing maintenance and troubleshooting.

1.5 Given a Corrective Maintenance Work Order describing a fault in an Excore Safety Channel Drawer, , troubleshoot the system in accordance with the applicable work order to determine the nature of the fault.

TO: 1 **Given the appropriate reference material and the necessary test equipment, the I&C Technician will, troubleshoot and maintain the Safety Range Excore System. Mastery will be demonstrated by successfully completing a lab practical evaluation.**

EO: 1.1 **Describe the function and operation of the major circuits utilized in the Safety Range Excore System, including inputs and outputs and discuss Prevent Event Tools and Electrical Safe Work Practices that can be use to minimize human performance errors.**

Main Idea

1. Safety Range Excore System Overview
2. Overview
3. Four Safety Channels (A, B, C, & D) provide neutron flux information over a range of 10 decades (2 x 10^{-8} % to 200%) and consist of:
4. Three fission chamber detectors
5. Preamp
6. Signal processing drawer containing:
7. Power supplies
8. Logarithmic amp
9. Linear amp
10. Test circuitry
11. Rate of change
12. Provide input signals to the PPS and CPC to provide the following plant trip functions:
13. PPS
14. Variable Overpower (VOPT)
15. High Logarithmic Power
16. CPC
17. Departure from Nucleate Boiling Ratio (DNBR)
18. Local core Power Density (LPD)

Dwg N001-13.04-154

VTD pages 1-6 thru 1-8, section 4.1.2.

19. Reactivity Management

TCS 97-2418

20. Trips the reactor by dropping rods via PPS– negative reactivity addition
21. By design
22. Setpoint is exceeded on parameters 1 or 2 directly
23. CPC calculation for parameters 3 or 4 indirectly
24. Inadvertently meeting the 2 of 4 logic required to trip the reactor due to a human performance error
25. General Description
26. Detector Assembly

VTD page I-13, section 4.3.1 Dwg N001-13.04-154

27. Stacked vertically for axial power shape measurement
28. Operated in current mode in the power range of 0% to 200%
29. Center chamber is used as a wide range detector from 2 x 10^{-8} % to 200% in the log range
30. Preamplifier/Filter Description

VTD page I-13, section 4.3.2.

31. Electrical Location – Between the Detectors and the Signal Processing Drawers.
32. Physical Location
33. Channels A & B – Outside containment.

Provides Post Accident indication – moved outside Containment per Reg Guide 1.97 (VTD IV-22)

34. Channels C & D – Inside containment annulus.
35. Preamp

Dwg N001-13.04-154

36. Conditions the pulses received from the center detector and drives the signal to the processing drawer.
37. Converts negative pulses to positive voltage pulses

38. Provides for remote application of a test signals into the preamp
39. Filter provides a distribution point for the high voltage from the signal processing electronics
40. Signal output is routed to both the Logarithmic circuit and the Linear circuit
41. DC current from the upper and lower detector chambers are fed directly to the drawer
42. Signal Processing Drawer Description

VTD page I-14, section 4.3.3. Dwg N001-13.04-87

43. Two Sections

44. Log Section

45. Linear Section

46. Log Circuit

47. Pulse signals from the pre-amp are sent to a logarithmic circuit which has two parallel paths:
48. Log section - Counts individual pulses, for the lower 6 decades.
49. MSV Section - Measures the mean square AC RMS voltage of the signal for the upper 4 decades.
50. Log Section includes:

51. Discriminator card which filters out noise and signals from sources other than neutron interaction
52. Log Count Rate card which produces a DC output voltage proportional to the log rate of the input count rate
53. Used from 2×10^{-8} % to 2×10^{-2} % power

54. MSV section

55. MSV card provides a DC output proportional to the the mean square of the AC input signal
56. Used from 2×10^{-2} % to 200% power

57. Combinational Card

58. Combines signals from LCR and MSV card into a smooth and continuous 0 to +10 vdc output

59. Only one of the two will provide an output from the CC card
60. Analog outputs
61. Power level signal for a local meter
62. Power level signal to parameter 4 PPS bistable card (via J23 bistable card and Log Calibrate switch S1) as an input for the High Low Power Trip
63. Power level signal to control room recorder on B05 (via J28 buffer card)
64. Power level signal to remote shutdown panel (A and B only via J27 buffer card)
65. Power level signal to the Rate of Change circuit (via J23 bistable card, Log Calibrate switch S1 and Rate Calibrate switch S3)
66. Rate of change to a local meter
67. Rate of change to a control room indicator (via J28 buffer card)
68. Analog input to the bistable card J23
69. Bistable outputs
70. LOG 1 (at 1.6×10^{-4} % pwr increasing) provides a permissive to bypass the HI LOG TRIP (via J23 bistable card).

Trip will automatically reset (per Tech Spec requirement) when power goes below the setpoint

71. LOG 2 (at 6.3×10^{-5} % pwr increasing) automatically enables (per Tech Spec requirement) the CPC trip for DNBR and LPD (via J23 bistable card).

Allows the operator to bypass the CPC trips when power goes below the setpoint

72. Rate, Trips (at +2.5 DPM) for an alarm (via J24 bistable card).
73. Linear Section

VTD page I-15, section 4.3.3 Dwg N001-13.04-87.

74. DC current signals from each fission chamber section is applied to a linear amp for conversion into a voltage signal.

75. Outputs are also averaged and sent to a amp with remote gain adjust which allows the summed power to match the plant thermal power (Derived from a calorimetric calculation).
76. Analog outputs

77. Each subchannel output is sent to the CPC, for calculation of LPD and DNBR PPS trips (parameters 3 and 4)
78. CAL SUM is sent to the PPS for the VOPT bistable (via Linear Calibrate switch S5, and J28 buffer card)
79. CAL SUM is sent to a recorder in the control room (via J28 buffer card)
80. PPS DVM (via Output Select switch S10)

81. Bistable outputs - LINEAR (at 15% power increasing).

NOTE: The earliest CE design originally called for a Loss of Load Trip, driven by Main Turbine stop valve position switches processed via PPS. To allow for turbine loading instabilities, the trip was not enabled until 15.2 Rx power. Since PVNGS, via RPCB & SBCS, can handle a Loss of Load event of any magnitude, no PPS trip/bypass at 15% is needed.

82. Trouble Circuit alarms (NI INOP) if any of the following conditions occur:
83. Loss of a high voltage power supply

84. Removal of any card

85. Loss of circuit low voltage

86. Powering down the drawer

87. Any Trip Test switch out of the OFF position

88. Any CALIBRATE switch taken out of its OPERATE position

89. Has the potential to cause a LPD and DNBR trip for the associated channel, if parameters 3 and 4 aren't bypassed

Can refer to Dwg N001-13.03-1845 of the PPS system

90. Test circuits allow injection of a test signal for each amp

91. Log driver amp

92. Rate amp

93. Three linear subchannel amps

94. Fault Protection Circuit - keeps signal common below 270 VDC if the detector high voltage shorts to ground.

95. External SCALER Output - allows monitoring output of the pulse height discriminator at low power levels.

96. Safety Channel Circuit Operation

97. Detector

TP02 Detector Line Diagram

98. The detector assembly is known as the thimble

99. Housed in a well next to the reactor

VTD page I-29

100. Supported in the well by use of locking springs

VTD page III-77, dwg N001-13.04-32

101. Electrically insulated from the well

102. An assembly is made up of three detectors

103. In the power range the fission chambers operate in the DC current mode and are sent to the LAS-1 card

104. Center detector is used in the counting mode and Mean Square Voltage mode (also known as AC mode)

105. Linear Amp and Summer Card Descriptions (LASI-1).

VTD page IIA-28, 29, 30 and 31, section 3.6.1 Dwg N001-13.04-56

106. Purpose

107. Accepts the DC current from each of the detector sections, converts the current to a voltage
108. Amplifies and averages the voltages (linear circuits)

109. Circuit Description

110. First Stage Amplifiers.

111. Serve as I/E Converters

112. Accept 0 to .2ma current signals from the detectors

113. If the input cable for the detector subchannel were removed, the cable charges up to - 800VDC, this could damage the op amp if reconnected.
114. When the cable is to removed, it should be placed on the input shorting jacks.
115. Before the cable is reconnected, place the Linear calibrate switch in the Zero position, even if the HV is off. (This eliminates the chance of static charge build up being a problem.)

PREVENT EVENTS: *What kind of Prevent Event tools can or are utilized during the performance of ST's to ensure the above steps are performed?*

Place Keepers: Anytime the cables are disconnected or reconnected the STs provide sign-off steps that provide the required directions to prevent the cables from building a charge

Communication: Repeat backs as the task is being performed. "Removing P8 from J8…………Connecting P8 to J14 INPUT SHORTING JACK

Self Check/Peer Check: Managements expectation that both techs participate in both aspects of the work performance

What kind of Prevent Event tools can be used during the performance of a CM when the only time the precaution associated with the ensuring the shorting jacks and the linear calibrate switch are used to prevent a charge from building up are mentioned in the front of the package only?

Self Check/Peer Check: Provide a verbal re-enforcement of the requirement

Place Keeper: Placing a visual reminder on or above the drawer of the cable requirements for disconnecting or reconnecting

116. Second Stage Amplifiers

117. Provide a gain adjustment, so the output of each amp can be adjusted for +10VDC at 200% reactor power (100% span).

118. The second stage outputs are independently sent to the CPC for calculation of Axial Power Distribution and to the Summer Amp Stage.

119. Power Summer Amp A7 - inverts and sums the subchannel outputs and divides the resultant by 3 (averages).

120. Cal Sum Amp A8 - final stage employs feedback from the Remote gain pot on the remote module to allow adjustment for the plant calorimetric calculation

121. Alpha Test Card

122. A means of checking continuity of the detector is provided in the first stage of each linear subchannel.

123. Pressing the appropriate alpha test pushbutton on the alpha test card, opens the normal feedback path of the first stage amp and inserts a gain of 48.

124. The greatly increased sensitivity of the amp will detect the small current caused by alpha decay in the fission chamber even when no flux is present.

125. Trip Test input is an additive signal that is applied to the inputs of the First Stage Amplifiers.

126. R36, R39, & R42 provide 200% test signals to the first stage inputs via the LINEAR CALIBRATE switch when it is in the 200% Position.

127. Preamplifier/Filter Assembly Operation.

128. Electrical Line Diagram for the center detector

Tech Manual, Tab 2; TCS 98-1434

129. High Voltage from the drawer (-800vdc)

130. High Voltage filter – common is floating

131. Detector assembly

132. HV lead

133. Signal lead

134. Inner shield

135. Outer shield

136. Detector holder

137. Preamp – commons are tied to the case

138. Original problem was noise induction causing the log channel “C” in Unit 1 to read higher than the other three channels when low in power
139. High voltage filter

140. Coax cable at the input of J6

141. Three triax at the output

J3 is the output jack associated with the middle detector

142. –800vdc applied from E5 to E2

143. E6 is the return to the positive side of P3

144. E4/E6 are the filter circuit common and connected to the inner shield of the detector
145. Outer shield is connected to the filter case via the connector
146. Preamp

147. Triax cable at the input jack J8

148. Coax cable at the output jacks J10 and J7

149. Log signal from E1 to E11

150. Linear signal from E1 to E12

151. Inner shield connected to E15 and the amp case

152. Outer shield is connected to the case via the connector
153. This configuration allows the outer shield to act as an antenna thus inducing a signal into the amp when any noise exists
154. Solution was to reference the open end of the outer shield at the filter (J3) to a common reference
155. Eliminates the outer shield as an antenna

156. Accomplished by using a shorting strap from the preamp case to the filter
157. Done for channels C and D only in all three units
158. Already existed in channels A and B at the cable clamp box located in containment
159. Filter Assembly

VTD section III, figure 14

160. Purpose
161. Terminates the detector HV cables to the correct impedance to allow for maximum power delivery to the load.
162. Three detectors are fed by single HV cable from control room.
163. Filter eliminates noise induced on the HV supply cable.
164. Circuit Description
165. R1, R2 and R3 are used to match impedance of detector HV cables.
166. Three low pass filters, one for each output.
167. R13 and C13 are used to match impedance of HV supply cable.

ELECTRICAL SAFE WORK PRACTICES: *Even though no electrical PPE is required to work on the excore drawers, the risk of electrical shock (without causing bodily harm) is still present due to the -800 vdc power supply for the detectors. What type of precautions should be use to prevent electrical shock and/or shorting from the HV power supply?*

> *Self Check/Peer Check: Only one technician will be performing work on the drawer, but it is managements expectation that both will participate in the monitoring of each other during the performance of the task.*
>
> *Use of Insulated Tools: Will be used when working on or near exposed live parts. Ask the students what the requirements are for the use of insulated tools.*
>
> > *Must be rated for the voltage they are to be used on*
> >
> > *They are to be used as secondary protection (don't' take the place of protection equipment)*
> >
> > *Must be clearly rated with the voltage label*
> >
> > *Visual inspection prior to use (any damage and the tool shall be labeled as "Defective Equipment" using an "Out of Service" tag)*
> >
> > *Non-insulated tools shall not be used closer than the Restricted Approach Boundary to live parts unless they are insulated and meet Section Leaders Approval*

168. Preamplifier Assembly

Dwg N001-13.04-195

169. Purpose

170. Converts the input from charge to voltage.

171. Provides sufficient amplification to drive signal up to 500 feet.

172. Input signals are negative pulses, and the output polarity is inverted (positive pulses)

173. Provides pulse shaping.

174. Circuit Description

175. C5 provides DC isolation but couples AC signal.

176. R51, C5, and Q3 match input impedance of detector signal cable.

177. Clamp CR1 protects Q3 from transients.

178. Relay R1 switches Q3 input from detector signal to calibration capacitor C1.
179. C1 is used to convert AC voltage at junction of R1 and R46 into a known charge.
180. K1 picks up at -1.5 VDC.

181. Q1 thru Q9 form a direct-coupled, inverting amp with a balanced emitter - follower output.
182. Using FET's provides for low internal noise and high open-loop gain.
183. Q10 thru Q15 form the output stage, arranged as a broad-band operational amplifier.
184. Preamplifier output signals must be properly processed to be useful.
185. Proper termination impedance must be maintained on the pre-amp output (75 ohms for A&B, 93 ohms for C&D).

186. Discriminator/Driver Card Description

VTD page IIA-31, section 3.6.2 Dwg N001-13.04-112

187. Purpose

VTD page IIA-20

188. Receives the pulses from the pre-amp.

189. Amplifies pulses, discriminates pulse height.

190. Outputs a square wave pulse count for every fission event.
191. Circuit Description

192. Receives pulses (in parallel with the MSV card) from the pre-amp.
193. A1 Amp

194. High speed pulse amp

195. Gain of 2.2

196. Buffers A2 from the preamp cable

197. Provides noise filtering

198. Output is positive pulses typically over 100 mv in amplitude
199. A2 Amp

200. Comparator that passes pulses of an amplitude higher than the discriminator threshold.
201. Reference voltage for the threshold is set by R6 (between 80 and 90 mv)
202. A4/A5 Amps (A4, A5 & A6).

203. Monostable multivibrator (one shots)

204. This outputs a square wave to the Log Count Rate card

205. 500 nsec pulse output from A4 (to scaler output jack)

206. 100 nsec pulse output from A5 (to LCR card)

207. Log Count Rate Card Description (LCR).

VTD page IIA-32, section 3.6.3 Dwg N001-13.04-111.

208. Purpose - produces a DC voltage output which is proportional to the log of the input pulses
209. Circuit Description
210. Accept the square pulse count from the DD1 card.
211. A1 produces a 10 meg clock, which is fed to decade dividers A 3, 5, 7, 9, 11, 13, 15 & 17.
212. These outputs are fed in parallel to "D" flip flop inputs A - 2, 6, 10, 14 & 16.
213. Square pulses from the DD1 Ckt. feeds all the F/F reset inputs in parallel.
214. All F/F receive the same reset (neutron pulse) freq., but different clock pulse freqs.
215. Each F/F Q not outputs are sent to a NAND Gate which inverts the signal then sends it to the input of A19, in parallel with the other NAND gates.
216. A19 Sums the inputs and provides an inverted output.
217. With no counts inputted from the DD1, all the F/F outputs remain set and the Q not is 0, Nand gate output is 1.
218. As pulses are inputted, each F/F is reset, causing the Nand gate output to go to 0.
219. The clock pulses at different freqs will cause the F/F Ckts. to set at various freqs.
220. The ratio of clock freqs. to input pulse freq. in each stage will determine how long each stage remains reset.
221. Each Nand gate will exhibit an average output voltage that is related to the input count rate.
222. The output of A19 is biased to 0 at very low count rates.
223. A18, with R38 provides the scaling adjustment, so that a slope of one volt output for each decade increase in input can be achieved.
224. Mean Square Voltage Card Description (MSV).

VTD page IIA-33, section 3.6.4 N001-13.04-51

225. Purpose:
226. To provide a DC output indicative of the log of the input pulse rate for the higher decades, where DD1/LCR ckts can't count individual pulses because of pulse overlap.

227. The purpose of the MSV card is to provide a DC output based on the premise that: "the RMS value of the AC component is proportional to neutron flux" (Campbell's theorem) while in the power range.
228. Circuit Description

229. The input is connected in parallel with the input to the DD1 circuit.
230. Processes the detector signals, beyond the range in which the DD1 ckt can function.
231. As power level increases, the pre-amp output pulses begin to overlap.
232. The signal becomes an AC voltage, whose Rms value is proportional to the Square root of the input count rate (Square of the RMS Voltage is proportional to reactor power).
233. Amps A1 and A2 form a band pass filter - passing 5 kHz to 100 khz at unity gain.
234. A3 provides a gain adjustment to compensate for different detector/ preamp sensitivity and cable attenuation.
235. A4 is the True RMS module which produces a DC output proportional to the RMS input voltage.
236. A5 is a log amplifier set up with a gain of Two.

$\text{Log}(x^2) = 2\ \text{Log}\ x$

237. The AC Rms voltage must be squared to represent power and the result must be amplified in a log fashion to produce a suitable output for the log scale.
238. A5 having a gain of two performs the squaring function.

239. A6 provides adjustment of the span and offset, in order to produce a smooth, continuous output with the LCR circuit at the crossover of the two ranges and to provide proper output for the 1 VDC increase in output for each of the upper four decades of power (6 to 10 VDC.)
240. Combinational Circuit Card Description (CC1)

VTD pages IIA-34/35 and 36 Dwg N001-13.04-50.

241. Purpose

242. Circuit acts as a unity gain amplifier (with adjustment capability) for the LCR circuit. (Outputs 0-6 vdc for the 6 lower decades.)
243. Circuit acts as a unity gain amp (with adj) for the MSV circuit (the upper four decades.)

244. Except at the crossover region, only one of the two Ckts. will provide an output.
245. The crossover region is a 200 mv region beginning at 6.0 Vdc, where one ckt gradually phases in while the other gradually phases out
246. This prevents spurious rate indication due to any slight miscalibration between these two circuits
247. Circuit Description
248. Amps A6 and A7 are XY multipliers with a transfer function of XY/10 = voltage.
249. LCR ckt output to the Y input of A7. MSV output applied to the Y input of A6.
250. When Rx power = 2×10^{-2} (LCR VDC = 6.0). The X input of LCR multiplier A7 is held at 10.0 VDC and the X input of A6 is held at 0 Vdc.
251. As power increase above this point, over a 200 mv span, the x coefficient for LCR (A7) linearly approaches 0 volts and the X Coefficient for MSV (A6), linearly approaches 10 Volts.
252. The crossover network consist of Amp A1, 10 volt clamp A2, 0 volt clamp A3, LCR X coefficient Generator A4, and inverting amp MSV X coefficient generator A5.
253. A1 has a gain of -50 (50, inverting) and is biased by R3, so that its output will be greater than 10 volts whenever the LCR input is not sufficiently high (6.0 volts) to force it lower.
254. A2 clamps A1 output to 10 Volts.
255. A4 provides the x input to A7 (LCR) and the input to A5.
256. A5 provides the X input to A6 (MSV) and is biased with -10 volts.
257. This places 0 volts on the X input of A6, causing the MSV portion to be cut off.
258. At crossover point, A1 output goes toward the negative power supply voltage, but is clamped to 0 volts by A3.
259. This causes the MSV ckt to produce a signal output and cuts off the LCR ckt.
260. A8 is used as a Summer.
261. A9 is used as a scaling adjustment for the combined output which spans a total of ten decades (10 vdc).
262. Testing
263. Trip Test- additive signal that is applied to the input of the A9 amp

264. LOG CALIBRATE

265. Discrete signals selected by the LOG CALIBRATE switch and applied to the pre-amp
266. MSV position disables the LCR portion of the CC card

267. Rate of Change Power Circuit

VTD page IIA-36, section 3.6.5.1 Dwg N001-13.04-50

268. Purpose

269. Circuit is located on the CC1 card, but operates independently.
270. Rate of Change is used for display and alarm purposes only, there is no trip functions directly associated with it.
271. Provides indication of the Rate of Change of RX power, expressed in Decades per Minute (DPM).
272. Circuit Description

273. A10 is a differentiator, which provides an output proportional to the rate of change of power.
274. Receives the power signal from the output of A9 thru RATE CALIBRATE switch on the front panel.
275. A11 drives the output and provides for scaling and bias.

276. The Output changes by 1.25 volts for each DPM.

277. The range of the circuit is -1 to +7 DPM. Zero point - output = 1.25 VDC.
278. Test Inputs

279. Trip test is additive and applied to the A11 amp

280. RATE CALIBRATE applies 7 DPM signal from the test card to the input of A10
281. Bistable Trip Assembly Card Description

VTD page IIA-37, section 3.6.6 N001-13.04-57.

282. Purpose - provide contact outputs as specific trip setpoints which are used for trip and alarm purposes
283. Circuit Description

284. Each bistable card has:

285. 3 circuits

286. Relay can energize on increasing or decreasing parameter, depending on jumpers.
287. R3 and R4 provide the Setpoint adjustment.

288. R5 provides a 1% hysteresis.

289. SCR1 is off when the relay K1 is energized.

290. With the jumpers straight, the relay is energized with the input above setpoint.
291. Q2 and Q3 are used to drive SCR2 and Q4.

292. Q4 drives K1.

293. SCR1 or SCR2 is used to drive memory lamps on the front panel.
294. Once the SCR fires, it will continue to conduct until the input falls to 0.
295. Lamps remain lit on the front panel until the alarm condition clears and the front panel switch is depressed which interrupts input to the SCR.
296. Fault Protection Circuit/HV Monitor Card Description.

VTD pages IIA-38 and 39, section 3.6.7 Dwg N001-13.04-58 TP03 Fault Protection Circuit

297. Purpose

298. Prevents signal common from rising to some large voltage should the high voltage short to ground.
299. HV monitor provides a meter reading of HV value and feeds the trouble bistable.
300. Circuit Description

301. The fault protection path is - Ground, R1, R2, R3, CR1 & CR2, R4 then common.
302. CR1 and CR2 present a large resistance between common and ground.
303. If a fault occurs, the diodes will break down at 24 volts and conduct.
304. HV power supply is limited to 15mA so the difference between common and ground is limited to under 270 volts.

305. The path of R6, R5 to common provides a means of monitoring the circuit with the PPS DVM.
306. CR 3&4 prevent the input to the DVM from exceeding 20 V.
307. Testing of the circuit is by introducing 30 volts (utilizes the ±15vdc power supplies) with a test switch then monitoring the change on the DVM.
308. TEST+ inputs +15vdc at pin 9 and –15vdc at pin 7
309. TEST- inputs –15vdc at pin 9 and +15vdc at pin 7
310. HV monitor receives a 0 to +5 VDC signal from the HV power supply which corresponds to an output of 0 to 1000 VDC.
311. The HV monitor amp doubles this signal and uses it to drive a local meter and power the trouble bistable loop.
312. Buffer Assembly Card Description

VTD page IIA-39, section 3.6.8 Dwg N001-13.04-145

313. Purpose - protects the safety channel drawer from external faults propagating along the signal output lines from remote indicators or recorders.
314. Circuit Description - consists of four optically coupled isolation amplifiers and a DC/DC converter module power supply
315. Test Circuitry
316. Log Test Circuitry

VTD pages IIA-39, 40 and 41 Dwg N001-13.04-88 and N001-13.04-87

317. Test Card
318. Purpose – allows the operator to check the normal operation of both the logarithmic and rate circuits
319. Log signal is applied to the preamp and sent back to the drawer
320. Circuit Description
321. A1 generates a clock frequency of 9.216 MHz which is divided by A2, A3, A4, A5, and A6.

322. The correct frequency for each calibrate position is selected by expander A9 and fed to one shot A7 where the pulse widths are adjusted for 1 microsecond for LCR calibration or 5 microseconds for MSV with K1 and R17 or R18.
323. The selected pulse is then fed to level translator A8 which converts the TTL pulses to an output of identical frequency and width, but -15 VDC in amplitude.
324. Pulse height selection is effected in potentiometer chain R19 thru R23 which is selected by K2, 3, 4 or 5.
325. The LCR test signals vary in frequency but the MSV test signals are the same frequency and different amplitude.
326. The signal is sent to A10, a unity gain driver which can drive several hundred feet of cable to the preamp input.
327. R9 generates a -1.5 volt offset on which the pulses ride.
328. This offset energizes a relay in the preamp which substitutes the test pulses for the detector and shorts the detector input to ground.
329. CR2, a 10 V zener substitutes a 10 volt output for the normal log output to the protection system or for the linear output to protection system when the TEST/OPERATE switches are out of CALIBRATE/OFF.
330. Log Calibrate Switch (S1)
331. Six position switch: LCR1 through LCR3 and MSV4 through MSV6
332. Deck 1 and deck 2 apply the ±15vdc to the test card
333. Deck 3 applies the +5vdc to the test card
334. Deck 4 applies 5vdc to pick up either K2, K3, K4 or K5 on the test card
335. Deck 5 places signal common to the LCR or MSV enable inputs on the test card
336. Deck 6 places 10vdc to the Log High Power or the VOPT PPS bistables cards based on either S1 (log) or S5 (linear) taken out of OPERATE
337. Deck 7 disables the LCR circuit when the calibrate switch is placed in any of the MSV positions
338. Deck 8 interrupt the trouble circuit when S1 is taken out of OPERATE

339. Deck 9 ensures the pulse width for the test signal associated with the MSV positions changes to .5 microseconds by applying 5vdc to the K1 relay on the test card
340. Log Trip Test Switch (S2)
341. Outer knob to energize the circuit and an inner knob that is a potentiometer
342. 12 vdc from PPS aux power supply applied to the log trip test interlock relay
343. PPS bistable pushbutton isn't depressed
344. No matrix testing in progress
345. –15vdc applied through the potentiometer
346. Signal is applied from the pot on S2, through log trip test interlock contact, back through S2 and to pin 12 of CC1 card
347. Signal is additive
348. Linear Test Circuitry
349. Linear Calibrate Switch (S5)
350. Isolate the cables from the drawer and inserts the test signal through the switch to the LAS-1 card
351. Two position: ZERO and 200%
352. Decks 1, 2 and 3
353. Ensure the cables are grounded when the switch is in either position
354. Route 10 volts from the LAS-1 card (pins 19, 20, and 21) through the switch and back to the LAS-1 card input (pins 14, 15 and 16) when 200% is selected
355. Applies signal common to the LAS1 card (pins 14, 15 and 16) when ZERO is selected
356. Deck 5 applies +15vdc to the test card (pin 8)
357. Deck 6 routes 10vdc from the test card (pin 9) through the switch to buffer card J28 pin R and to the VOPT bistable in PPS via J13-V/W
358. Linear Trip Test Switches (S6, S7 and S8)

359. Doesn't break the circuit, the test signal is additive to the already existing signal
360. Outer knob lines up the potentiometer and the inner know is the potentiometer
361. –15vdc applied across the pot
362. Each pot supplies an input to its associated subchannel amplifier on the LAS-1 card (pins R, S and T)
363. Rate Test Circuitry
364. Rate Calibrate Switch (S3)
365. Two position: ZERO and 7 DPM
366. Breaks the circuit from the log input
367. Applies the ±15vdc to the rate portion of the test card
368. Zero position, signal common is applied through the switch and to the CC1 card, pin 14
369. 7 DPM position
370. Test voltage from the test card (pin 2) is sent to the switch

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371. Sent back to the test card (pin 4) and to the input of the integrator (ramp circuit)
372. Provides a ramp increase in the voltage of 7 volts per minute, responding to a 7 DPM start up rate (pin 3 of the test card)
373. Back through the switch and to the CC1 card (pin 14)
374. Rate Trip Test Switch (S4)
375. Outer knob aligns the test pot, inner know is the pot
376. The test signal is additive to the already existing signal
377. -15vdc is across the pot
378. signal is applied from the switch to the CC1 card (pin 15)

EO: 1.2 Describe the function and purpose of all front panel indications and controls on an Excore Safety Channel Drawer.

Main Idea

379. Safety Channel Excore Controls and Indications

380. Log power meter monitors logarithmic power levels from 2E-8 to 200% power.

381. LOG CALIBRATE switch takes signals from test card and applies them to the system inputs through a preamp.

382. LOG TRIP TEST pot provides an additive signal to the signal already present. Functionally checks the related bistable LOG1, LOG2 setpoints.

383. SCALER jack monitors the output of the pulse height discriminator at low power.

384. LOG lamp display visually indicates when the trip setpoints of LOG1 and/or LOG2 have been exceeded.

385. HIGH VOLTAGE meter monitors the HV power circuits.

386. FAULT PROTECT switch when in TEST position, checks functional integrity of the fault protect circuit.

387. TROUBLE lamp switch when illuminated indicates loss of low voltages or HV, removal of a module (PC card), placing a calibration or test control in other than the operate or off position.

388. AC POWER lamp actuates (lights) when power is applied to unit.

389. Rate meter measures the rate of change of power.

390. RATE CALIBRATE switch applies a ramp signal to the input of the rate circuit on card CC1.

391. RATE TRIP TEST pot provides an additive signal to the signal already present, functionally checks the bistable setpoint.

392. Rate lamp switch combination of both switch and lamp. Visually indicates trip point of rate bistable.

393. OUTPUT SELECT switch provides capability of monitoring various circuit functions at PPS DVM.

394. LINEAR POWER METER measures the individual and summed linear subchannel power levels.

395. LINEAR CALIBRATE switch provides a simulated signal to linear sub 1, 2, 3 outputs.

396. METER SELECT switch selects and applies the various outputs of the linearity circuit to the LINEAR POWER METER.

397. Linear lamp switch combination switch and lamp visually indicates the trip point of the corresponding bistable circuit (if it were used).

398. LINEAR TRIP TEST switch 1 thru 3 provides an additive signal to the signal already present. Functionally checks the related bistable setpoints.

399. Power on switch on top of chassis applies power to safety channel drawer.

EO: 1.3 State the conditions which will cause a trip signal to be generated in the Plant Protection System from the Safety Channel Drawer.

Main Idea

400. Maintenance Precautions

401. General Precautions

402. The safety channel Excores are safety related and Tech Spec items.
403. Operation covered by Improved Tech Specs and LCOs (Limiting Conditions for Operation) could be involved.
404. Permission to perform maintenance must be obtained from the Shift Manager or Control Room Supervisor and the Control Room Operator must be aware of what effects to the plant should be expected.
405. Do not place test equipment on top of drawer; interaction with counting circuits could occur.
406. Voltages of up to -1000 VDC are present.

407. Isolation transformer must be used for test equipment powered by other than battery.
408. When inserting and removing the extender or circuit board, turn power off.
409. Safety channel drawer weighs 75 lbs. Caution should be used while handling.
410. Cable precautions

411. If any cables are removed, they should be connected to the shorting jack
412. Prior to reconnecting any linear input cable to the rear of the safety channel, place the LINEAR CALIBRATE switch in the ZERO position to discharge the input cables and prevent input amp damage
413. When extending or reinserting the safety channel drawer, have one tech monitor the cables to insure that sufficient slack is present in all cables to prevent stressing the cables and/or connectors.
414. Electrical Charge Build Up On Cable J4 of Start-up Channel 2 in Unit 3 (CRDR 2692430)
415. Description

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416. Excore Control channel cal found connector J7 (Control Input 1) defective
417. Required:
418. Down powering the drawer
419. Disconnecting all cables
420. Removing the drawer
421. J5 (Startup HV cable) removed and discharged to J9 (Shorting Jack)
422. J7 and J8 (Control Channel signal cables) discharged to J11 and J12
423. J4 (Startup signal cable) was not since no HV present
424. Cables left loose while repairs were being done – 2 shifts
425. Drawer was re-installed, cables connected and powered up
426. Startup Calibrate switch placed in OPERATE
427. Count meter pegged high and HI CPS lite illuminated
428. Causes
429. Bad Startup Calibrate switch
430. Bad discharge connector J9
431. HV discharge resistor on pre-amp defective connection
432. HV cable shield between pre-amp J5 connector and amp drawer J5 connector not grounded
433. Corrective Actions
434. Discharge the Startup HV cable prior to disconnecting or reconnecting the Startup signal cable
435. Disconnect the Startup signal cable while the HV cable is connected to the shorting jack
436. Reconnect the Startup signal cable while the HV cable is on the shorting jack
437. Seismic Qualification of Bistable Control Panel (CRDR 2-9-0006) TCS 2831849
438. Background

439. Panel designed to be attached to the steel frame by 8 captive screws
440. Four screws spaced equal distance on each vertical side spaced evenly apart
441. Two screws were found disengaged
442. Cabinet mounted slide rails support the panel in the vertical direction and restricts side to side motion
443. When the cabinet front door is closed the door prevents panel movement in the forward direction without any secured captive screws
444. Evaluation
445. Four screws considered for the evaluation
446. With 4 screws, there exists a safety margin of 2
447. Conclusion
448. No impact
449. Four are sufficient, but 8 are still required
450. Minimum of 3/16" thread engagement needed for full effectiveness
451. Excore Safety channel requirements
452. Trip Signal Generation
453. Taking the LINEAR CALIBRATE switch out of operate will cause a VAR OVER PWR trip in addition to the DNBR/LPD.
454. Taking the LOG CALIBRATE switch out of operate will cause a HI LOG PWR trip in addition to the DNBR/LPD.
455. Trip descriptions
456. Variable Overpower Trip (Parameter 1) – provides a reactor trip to assist the ESF system in the event of an ejected CEA and the resultant rate increase

457. High Log Power Trip (Parameter 2) – to ensure the integrity of the fuel cladding and RCS boundary in the event of an unplanned criticality from shutdown due to a boron dilution or CEA withdrawal.
458. High Local Power Density Trip (Parameter 3) – CPC/CEAC provides decision based on flux distribution, CEA positions, heat transfer, Pressurizer pressure and RCP speed.
459. Low Departure from Nucleate Boiling Ratio Trip (Parameter 4) – CPC/CEAC provides decision based on flux distribution, CEA positions, heat transfer, Pressurizer pressure and RCP speed.

EO: 1.4 Describe how unwanted trips in the Plant Protection System are prevented while performing maintenance and troubleshooting.

Main Idea

C. Preventing Unwanted Trips

1. Ensure the proper bypasses are activated on PPS prior to taking any control switch out of OFF/OPERATE.

2. Secure power to the safety channel drawer for a minimum of 10 seconds whenever detectors are to be connected or disconnected.

EO: 1.5 Given a Corrective Maintenance Work Order describing a fault in an Excore Safety Channel Drawer, , troubleshoot the system in accordance with the applicable work order to determine the nature of the fault.

Main Idea

VIII The instructor will insert faults into the Excore simulator for the student to properly diagnose

SUMMARY OF MAIN PRINCIPLES

The following items are things to consider in your lesson summary. They are not mandatory. You should develop your own summary.,

Objectives Review

Review the Lesson Objectives

Topic Review

Restate the main principles or ideas covered in the lesson. Relate key points to the objectives. Use a question and answer session with the objectives.

Questions and Answers

Oral questioning

Ask questions that implement the objectives. Discuss students answers as needed to ensure the objectives are being met.

Problem Areas

Review any problem areas discovered during the oral questioning, quiz, or previous tests, if applicable. Use this opportunity to solicit final questions from the students (last chance).

Concluding Statement

If not done in the previous step, review the motivational points that apply this lesson to students needs. If applicable, end with a statement leading to the next lesson.

You may also use this opportunity to address an impending exam or practical exercise.

Should be used as a transitional function to tie the relationship of this lesson to the next lesson. Should provide a note of finality.