/lmg

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THE LIL MODULATORS INTERLOCK SYSTEM

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1. INTRODUCTION

As we wish to run the modulators at high energy there is a risk of breakdown but, should any fault occur, the equipment should automatically take the appropriate action. In our case this may be one of several operations depending on the origin and frequency of the fault. This note attempts to clarify the operation of the controls, interlocks and aquisitions of the modulators.

2. THE EQUIPMENT

For each klystron modulator there is an independant interlock system comprising 120 diffferent items each of which may operate at one of five levels, these are the status levels for the equipment. Therefore, a certain interlock will halt the modulator and bring it back to either "STANDBY, HEATING" or "OFF".

level 1...not used
level 2...pulsing
level 3...standby
level 4...heaters
level 5...off

The aquisition of interlock status is made directly into CAMAC by the relays themselves, the possibility of a bad reading for a good interlock is very remote. This aquisition passes through to the SMACC

(CAMAC controller) which processes the information and provides the video sceen image seen on the consoles and modulator racks.

The five status levels are used in the RELAY BOX to control the various supplies associated with the modulator, heating, focal, premagnetisation and D'qing. The request to go to a certain level of operation is received by the relay box and stored, the commands 'ON' 'OFF' and 'RESET' are sent to the equipment at the appropriate time, in normal operation the relay box would bring the equipment to the desired level without further intervention. If there is a fault during this sequence, or at any time in operation, one of the interlock levels will stay bad and the sequence will stop at this point until the fault is resolved or reset.

3. OPERATION

Modulator operation from "OFF" to "PULSING".

LEVEL 5.....OFF

For the modulator to be "OFF" all the controls interface is powered, the klystron vacuum pump is working, also thyratron cooling is operational. In addition, the following interlocks must all be good.

107 Klystron tank temperature.....high limit.....(max. 45.C.)
127 " heater voltage.....high limit..(approx. 10% above normal)
131 " " current.....high limit.. " " " "
137 Klystron ion pump voltage.....high limit.. " " " "
138 " " " " .....low limit... " " below "
141 Thyratron heater voltage.....high limit... " " above "
145 " " current.....high limit.. " " " "
147 " reservoir voltage.....high limit.. " " " "
151 " " current.....high limit.. " " " "
211 Klystron water flow.....(sum of body, focal, collector and window).
212 pressure switch Faraday Cage. (Ventilation for cooling filter, etc.)
(these last two are not yet memorised).

Only when all these conditions are good will the request for the

next level of control, which is heating, be passed.

LEVEL 5 is now good.MODULATOR STATUS=OFF

REQUEST:HEATING

START.....THYRATRON HEATER SUPPLY
THYRATRON RESERVOIR SUPPLY
KLYSTRON HEATER SUPPLY
TRIGGER AUXILLIARIES

The heaters require twenty minutes to reach temperature, for this condition the interlock 209 has a timer incorporated. To achieve "HEATERS ON" all the following interlocks must be good.

128 Klystron heater volts.....lower limit (nom. -5%)
129 " heater power..... high limit (nom. +5%)
130 " heater power..... low limit (nom. -5%)
131 " heater current..... lower limit (nom. -5%)
139 " vacuum pressure..... upper limit (70 uA)
140 " vacuum pressure..... lower limit (not used)
142 Thyratron heater voltage..... lower limit (nom. -5%)
143 " power..... high limit (nom. +5%)
144 " " .....lower limit (nom. -5%)
146 " current.....lower limit (nom. -5%)
148 " reservoir voltage..... lower limit (nom. -5%)
149 " power.....upper limit (nom. +5%)
150 " " ..... lower limit (nom. -5%)
152 " current..... lower limit (nom. -5%)

209 heaters delay..... (20 min.)
213 doors, covers, earthing, filter temperature.
214 H.V. enclosure
(these three are not yet memorised)

LEVEL 4...HEATING/HEATERS is now good.MODULATOR STATUS=HEATERS READY

The command for the next level of control will now be passed. A

fault in the list of interlocks for level 4 will stop this request but leave the heaters supplies "ON". A fault in level 5 will stop even the heaters and necessitate another 20 minutes heating.

REQUEST.....STANDBY

START.....HIGH VOLTAGE RELAYS
FOCALISATION POWER SUPPLY A
" " " B
" " " C
THYRATRON KEEP ALIVE SUPPLY
PREMAGNETISATION SUPPLY

The following interlocks must all be good to achieve "STANDBY":-

101 Klystron water input temp. (15-30.C)
103 Klystron water in-out temp. (5C max.)
105 Klystron water output temp. (15-30.C)

119 Focal A current..... high limit (ref. +5%)
120 " A " ..... low " (ref. -5%)
121 " B " ..... high " (ref. +5%)
122 " B " ..... low " (ref. -5%)
123 " C " ..... high " (ref. +5%)
124 " C " ..... low " (ref. -5%)

135 Klystron premagnetisation current ... high limit (ref. +5%)
136 " " " ..... low limit (ref. -5%)

153 Thyratron keep-alive volt ..... high limit (70 V)
154 " " " " ..... low limit (15 V)
155 " " " current..... high limit (0.1 A)
156 " " " " ..... low limit (0.3 A)

201 Access control)
205 R-F network vacuum pressure)
206 R-F network SF6 pressure)
207 R-F network water flow) these faults are not memorised
208 Trigger amplifier fault)

210 Standby delay (1 min.))
215 High voltage relays on (ROSS))

223 R-F reflected power ..... (600 mV.max) 3 faults/minute trip level
227 BUNCHER " " MDK 03 only (600 mV.max) "
229 Klystron voltage 2..... (V.nom +10%/-40%) "
232 Klystron current 2..... (I.nom +10%/-40%) "
234 Thyratron current 2..... (I.nom +10%/-40%) "
235 End of line current..... ..... "
236 Klystron over-voltage..... (V.nom +10%)....1 fault will trip

243 Material security....from d'qing supply
245 Rack covers "
246 Auxiliaries "
247 Water flow "
248 Thyristors fuses "
253 Voltage filter "
254 Primary current "
255 PFN short circuit "
256 D'qing current "
258 No measuring cable "
259 Line voltage "

LEVEL 3 is now good.MODULATOR STATUS= STANDBY

REQUEST...PULSING
SWITCH ON .....D'QING CONTACT BREAKER
TIMING ENABLE

The modulator should now run.

4. <u>TIMING INHIBIT</u>

When the modulator is operating, the dynamic interlocks play an important role in protecting the equipment, these are the pulse mesurements of thyratron voltage and current, klystron voltage and current, end of line current, RF reflected power and Lips reflected power. The pulse measurements work in two ways, the first is that any measured fault will cause a timing inhibit, stopping the modulator for

20 seconds to enable, for example, the vacuum pumps to clear some gas after a breakdown. The equipment will then restart again. If there are three faults of the same type within 40 seconds H.V. operation the pulse surveyor will cause an interlock to stop the modulator.

The clock is stopped during the timing inhibit, the number of faults accepted and the number of high voltage pulses are selected on each pulse surveyor card and the current rates may be changed in the future.

It should be noted that when a series of faults has been detected the pulse surveyor acts as an interlock which must be reset by the operator.

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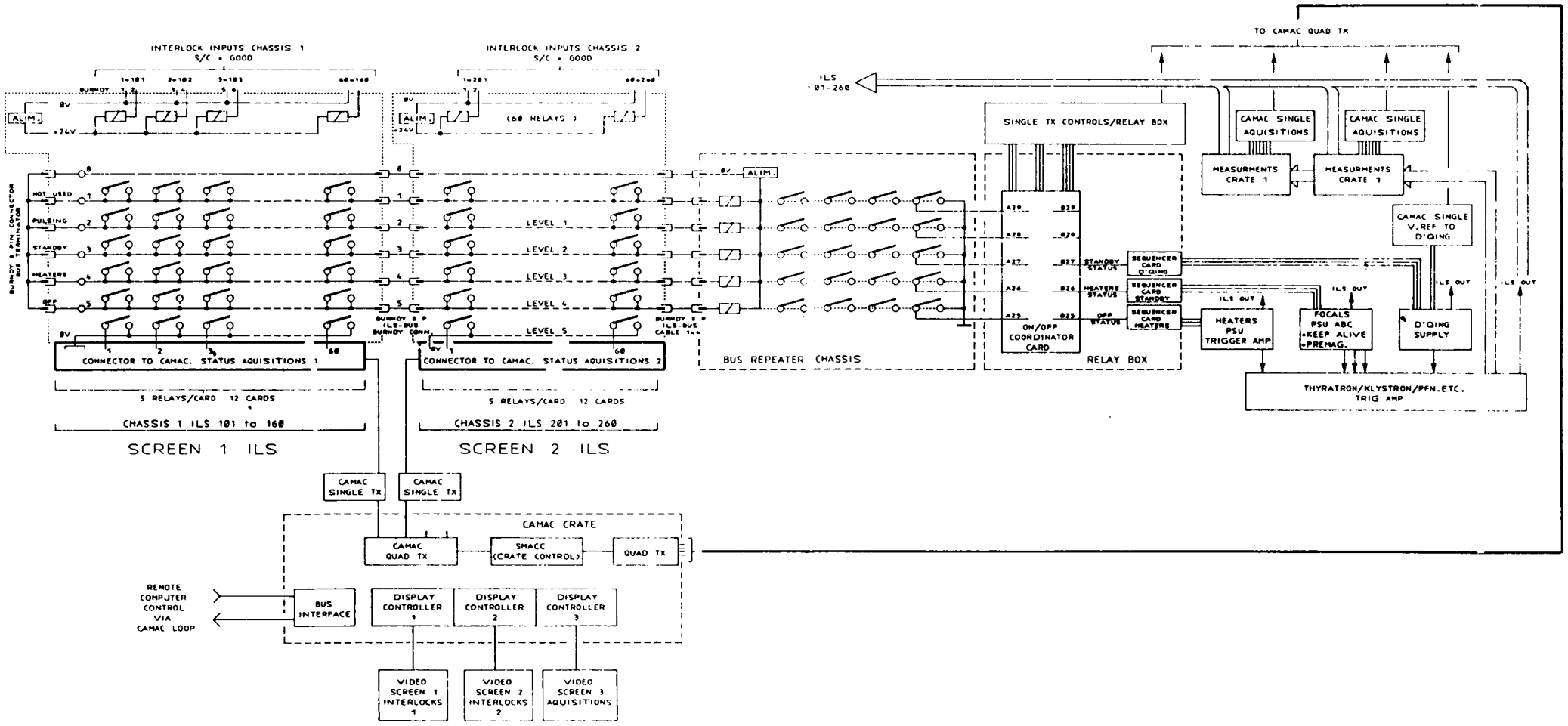
Annex : Interlock system drawing and flow chart.

Distribution : (Open)



INTERLOCKS SYSTEM LIL-MODULATORS	ECHELLE		NOM / DATE
		DESSINE	COEE V J-C 14-6-89
		CONTROLE	HUTCHINS 14-6-89
		N PS/PO	1114.99-1 14-6-89
		MODIFIE	
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CERN ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE / EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH	LIL 7EL 1088/2		INDICE

MODULATOR FLOW CHART

POWER ON :

1. MODULATOR RACKS:
   a) TV monitors
   b) measurement crates
   c) interlock
   d) singles transceiver
   e) HV relays interface
2. KLYSTRON VACUUM PUMP POWER SUPPLY
3. SHIELD. ENC. + THYRATR. FANS
4. HEATERS AUXILIARIES
5. AUXILIARIES D'QING POWER SUPPLY

6. THYRATRON HEATER
7. THYRATRON RESERVOIR HEATER
8. KLYSTRON HEATER
9. TRIGGER AUXILIARIES

10. HV RELAYS (ROSS)
11. FOCAL. POWER SUPPLY A
12. FOCAL. POWER SUPPLY B
13. FOCAL. POWER SUPPLY C
14. THY. KEEP-ALIVE ENABLE
15. PREMAGN. POWER SUPPLY

INTERLOCK :

DOWN

UP

OFF

HEATER ON

RESET

INTERLOCK LEVEL 5

bad

ok

DELAY 20MIN.

HEATER ON

STAND BY

RESET

INTERLOCK LEVEL 4

bad

ok

DELAY 1MIN.

LEVEL 5

- 107. KLY TANK TEMPERATURE
- 127. UP KLY.HEATER VOLTAGE
- 131. UP KLY.HEATER CURRENT
- 137. UP KLY. ION PUMP VOLTAGE
- 138. LO KLY. ION PUMP VOLTAGE
- 141. UP THY.HEATER VOLTAGE
- 145. UP THY.HEATER CURRENT
- 147. UP THY.RESERV.VOLTAGE
- 151. UP THY. RESERV. CURRENT
- 211. KLY WATER FLOW

212 PRESSURE SWITCH P.CAGE

LEVEL 4

- 128. LO KLY. HEATER VOLTAGE
- 129. UP KLY. HEATER POWER
- 130. LO KLY. HEATER POWER
- 132. LO KLY. HEATER CURRENT
- 139. UP KLY VACUUM PRESSURE
- 140. LO KLY VACUUM PRESSURE
- 142. LO THY. HEATER VOLTAGE
- 143. UP THY. HEATER POWER
- 144. LO THY. HEATER POWER
- 146. LO THY. HEATER CURRENT
- 148. LO THY. RESERV. VOLTAGE
- 149. UP THY. RESERV. POWER
- 150. LO THY. RESERV. POWER
- 152. LO THY. RESERV. CURRENT
- ⇒ 209. HEATERS READY (KLY+THY)
- 213. SHIELD ENC. DOORS+EARTH STRAP
- 214. HV ENCLOSURE DOORS

DELAY 1MIN.

STAND-BY

PULSING

RESET

INTERLOCK LEVEL 3

bad

ok

16. D'QING POWER SUPPLY MAIN BREAKER (HIGH VOLTAGE)
17. TIMING ENABLE

LEVEL 3

- 101. KLY. WATER INPUT TEMP.
- 103. KLY. WATER OUT-IN TEMP.
- 105. KLY. WATER OUTPUT TEMP.
- 119. UP KLY. FOCAL. A CURRENT
- 120. LO KLY. FOCAL. A CURRENT
- 121. UP KLY. FOCAL. B CURRENT
- 122. LO KLY. FOCAL. B CURRENT
- 123. UP KLY. FOCAL. C CURRENT
- 124. LO KLY. FOCAL. C CURRENT
- 135. UP KLY. PREMAG. CURRENT
- 136. LO KLY. PREMAG. CURRENT
- 153. UP THY. KEEP-AL. VOLTAGE
- 154. LO THY. KEEP-AL. VOLTAGE
- 155. UP THY. KEEP-AL. CURRENT
- 156. LO THY. KEEP-AL. CURRENT
- 201. MACHINE CONDITION 1
- ⇒ 202. MACHINE CONDITION 2
- ⇒ 203. MACHINE CONDITION 3
- 205. R-F NETWORK VACUUM PRESS.
- 206. R-F NETWORK SF6 PRESSURE
- 207. R-F NETWORK WATER-FLOW
- 208. TRIGGER AMPLIFIER
- ⇒ 210. STANDBY READY
- 215. HV RELAYS ON (ROSS)
- 220. KLY R-F FORW POWER 1
- 221. KLY R-F FORW POWER 2
- 222. KLY R-F FORW POWER 3
- 223. KLY R-F REFLEC POWER
- 224. LIPS R-F FORW POWER 1
- 225. LIPS R-F FORW POWER 2
- 226. LIPS R-F FORW POWER 3
- 227. LIPS R-F REFLEC POWER (MOD 03 ONLY)
- 228. KLYSTRON VOLTAGE 1
- 229. KLYSTRON VOLTAGE 2
- 230. KLYSTRON VOLTAGE 3
- 231. KLYSTRON CURRENT 1
- 232. KLYSTRON CURRENT 2
- 233. KLYSTRON CURRENT 3
- 234. THYRATRON CURRENT
- 235. END OF LINE CURRENT
- 243. MATERIAL SECURITY
- 245. RACKS COVERS SWITCHES
- 246. AUXILIARIES
- 247. WATER FLOW
- 248. THYRISTORS FUSES
- 253. VOLTAGE FILTER
- 254. PRIMARY CURRENT
- 255. PFN SHORT CIRCUIT
- 256. D'QING CURRENT
- 258. NO MEASURING CABLE
- 259. LINE VOLTAGE

(FROM D'QING POWER SUPPLY)

+236. KLY. VOLTAGE (UPPER)

READY FOR PULSING

INTERLOCK

bad

ok

PULSING

LEVEL 2

- 219. TIMING INHIBIT
- 241. D'QING POWER SUPPLY MAIN BREAKER ON

● Interlock enable

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