

APPENDIX C

COMPUTER RELIABILITY COMPUTATION

FOR

PALO VERDE NUCLEAR GENERATING STATION
BALANCE OF PLANT ENGINEERED SAFETY
FEATURES ACTUATION SYSTEM

BECHTEL JOB 10407
PURCHASE ORDER 10407-13-JM-104

DECEMBER 13, 1978

PROJECT NO. 2192

GENERAL ATOMIC COMPANY
ELECTRONIC SYSTEMS DIVISION
P O BOX 81608
SAN DIEGO, CALIFORNIA 92138

790 104 06 78

MISSION TIME:0

COMPONENT RELIABILITY DATA TABLE

SUBSYSTEM COMPONENT	FAILURE RATE PER MILLION HRS	RELIABILITY FOR 0 HRS
INITIATING CHANNEL FOR FBEVAS, CREFAS, CPIAS	12.5	1
ACTUATING CHANNEL & RELAYS FOR FBEVAS, CREVAS, CPIAS	7.17	1
AC POWER SOURCE	40	1
DC POWER SOURCE	4	1
AC TO DC POWER SUPPLY	25	1
DC TO DC POWER SUPPLY	25	1
INITIATING CHANNEL FOR CREVIAS	15.8	1
ACTUATING CHANNEL FOR CREVIAS	7.87	1
LOP/LS MODULE		
A. TRIP SECTION	5.77	1
B. 2/4 AND OUTPUT	11.8	1
DGSS	11.6	1
ESF LOAD SEQUENCER	20.7	1

RELIABILITY BY SUBSYSTEM

SUBSYSTEM	RELIABILITY
POWER SUPPLY	1
FBEVAS	1
CREFAS	1
CPIAS	1
CREVIAS(SMCROA)	1
CREVIAS(HGCROA)	1
DGSS	1
LOSS OF POWER	1
LOAD SEQUENCER	1

TOTAL SYSTEM RELIABILITY FOR 0 HOUR MISSION TIME: 1

MISSION TIME:48

COMPONENT RELIABILITY DATA TABLE

SUBSYSTEM COMPONENT	FAILURE RATE PER MILLION HRS	RELIABILITY FOR 48 HRS
INITIATING CHANNEL FOR FBEVAS, CREFAS, CPIAS	12.5	.9994
ACTUATING CHANNEL & RELAYS FOR FBEVAS, CREVAS, CPIAS	7.17	.999656
AC POWER SOURCE	40	.998082
DC POWER SOURCE	4	.999808
AC TO DC POWER SUPPLY	25	.998801
DC TO DC POWER SUPPLY	25	.998801
INITIATING CHANNEL FOR CREVIAS	15.8	.999242
ACTUATING CHANNEL FOR CREVIAS	7.87	.999622
LOP/LS MODULE		
A. TRIP SECTION	5.77	.999723
B. 2/4 AND OUTPUT	11.8	.999434
DGSS	11.6	.999443
ESF LOAD SEQUENCER	20.7	.999007

RELIABILITY BY SUBSYSTEM

SUBSYSTEM	RELIABILITY
POWER SUPPLY	.999996
FBEVAS	.999999
CREFAS	.999999
CPIAS	.999999
CREVIAS(SMCROA)	.999999
CREVIAS(HGCROA)	.999999
DGSS	1
LOSS OF POWER	1
LOAD SEQUENCER	.999999

TOTAL SYSTEM RELIABILITY FOR 48 HOUR MISSION TIME: .999999

MISSION TIME:96

COMPONENT RELIABILITY DATA TABLE

SUBSYSTEM COMPONENT	FAILURE RATE PER MILLION HRS	RELIABILITY FOR 96 HRS
INITIATING CHANNEL FOR FBEVAS, CREFAS, CPIAS	12.5	.999801
ACTUATING CHANNEL & RELAYS FOR FBEVAS, CREVAS, CPIAS	7.17	.999312
AC POWER SOURCE	40	.996167
DC POWER SOURCE	4	.999616
AC TO DC POWER SUPPLY	25	.997603
DC TO DC POWER SUPPLY	25	.997603
INITIATING CHANNEL FOR CREVIAS	15.8	.998484
ACTUATING CHANNEL FOR CREVIAS	7.87	.999245
LOP/LS MODULE		
A. TRIP SECTION	5.77	.999446
B. 2/4 AND OUTPUT	11.8	.998868
DGSS	11.6	.998887
ESF LOAD SEQUENCER	20.7	.998015

RELIABILITY BY SUBSYSTEM

SUBSYSTEM	RELIABILITY
POWER SUPPLY	.999983
FBEVAS	.999997
CREFAS	.999997
CPIAS	.999998
CREVIAS(SMCROA)	.999997
CREVIAS(HGCROA)	.999997
DGSS	.999999
LOSS OF POWER	.999999
LOAD SEQUENCER	.999996

TOTAL SYSTEM RELIABILITY FOR 96 HOUR MISSION TIME: .999997

COMPONENT RELIABILITY DATA TABLE

SUBSYSTEM COMPONENT	FAILURE RATE PER MILLION HRS	RELIABILITY FOR 144 HRS
INITIATING CHANNEL FOR FBEVAS, CREFAS, CPIAS	12.5	.998201
ACTUATING CHANNEL & RELAYS FOR FBEVAS, CREVAS, CPIAS	7.17	.998968
AC POWER SOURCE	40	.994257
DC POWER SOURCE	4	.999424
AC TO DC POWER SUPPLY	25	.996406
DC TO DC POWER SUPPLY	25	.996406
INITIATING CHANNEL FOR CREVIAS	15.8	.997727
ACTUATING CHANNEL FOR CREVIAS	7.87	.998867
LOP/LS MODULE		
A. TRIP SECTION	5.77	.999169
B. 2/4 AND OUTPUT	11.8	.998302
DGSS	11.6	.998331
ESF LOAD SEQUENCER	20.7	.997023

RELIABILITY BY SUBSYSTEM

SUBSYSTEM	RELIABILITY
POWER SUPPLY	.999961
FBEVAS	.999994
CREFAS	.999994
CPIAS	.999995
CREVIAS(SMCROA)	.999993
CREVIAS(HGCROA)	.999993
DGSS	.999997
LOSS OF POWER	.999997
LOAD SEQUENCER	.999991

TOTAL SYSTEM RELIABILITY FOR 144 HOUR MISSION TIME: .999995

MISSION TIME:192

COMPONENT RELIABILITY DATA TABLE

SUBSYSTEM COMPONENT	FAILURE RATE PER MILLION HRS	RELIABILITY FOR 192 HRS
INITIATING CHANNEL FOR FBEVAS, CREFAS, CPIAS	12.5	.997603
ACTUATING CHANNEL & RELAYS FOR FBEVAS, CREVAS, CPIAS	7.17	.998624
AC POWER SOURCE	40	.992349
DC POWER SOURCE	4	.999232
AC TO DC POWER SUPPLY	25	.995211
DC TO DC POWER SUPPLY	25	.995211
INITIATING CHANNEL FOR CREVIAS	15.8	.996971
ACTUATING CHANNEL FOR CREVIAS	7.87	.99849
LOP/LS MODULE		
A. TRIP SECTION	5.77	.998893
B. 2/4 AND OUTPUT	11.8	.997737
DGSS	11.6	.997775
ESF LOAD SEQUENCER	20.7	.996033

RELIABILITY BY SUBSYSTEM

SUBSYSTEM	RELIABILITY
POWER SUPPLY	.999931
FBEVAS	.99999
CREFAS	.99999
CPIAS	.999992
CREVIAS(SMCROA)	.999988
CREVIAS(HGCROA)	.999988
DGSS	.999995
LOSS OF POWER	.999995
LOAD SEQUENCER	.999984

TOTAL SYSTEM RELIABILITY FOR 192 HOUR MISSION TIME: .99999

MISSION TIME:240

COMPONENT RELIABILITY DATA TABLE

SUBSYSTEM COMPONENT	FAILURE RATE PER MILLION HRS	RELIABILITY FOR 240 HRS
INITIATING CHANNEL FOR FBEVAS, CREFAS, CPIAS	12.5	.997004
ACTUATING CHANNEL & RELAYS FOR FBEVAS, CREVAS, CPIAS	7.17	.998281
AC POWER SOURCE	40	.990446
DC POWER SOURCE	4	.99904
AC TO DC POWER SUPPLY	25	.994018
DC TO DC POWER SUPPLY	25	.994018
INITIATING CHANNEL FOR CREVIAS	15.8	.996215
ACTUATING CHANNEL FOR CREVIAS	7.87	.998113
LOP/LS MODULE		
A. TRIP SECTION	5.77	.998616
B. 2/4 AND OUTPUT	11.8	.997172
DGSS	11.6	.99722
ESF LOAD SEQUENCER	20.7	.995044

RELIABILITY BY SUBSYSTEM

SUBSYSTEM	RELIABILITY
POWER SUPPLY	.999893
FBEVAS	.999984
CREFAS	.999984
CPIAS	.999987
CREVIAS(SMCROA)	.999981
CREVIAS(HGCROA)	.999981
DGSS	.999992
LOSS OF POWER	.999991
LOAD SEQUENCER	.999974

TOTAL SYSTEM RELIABILITY FOR 240 HOUR MISSION TIME: .999984

MISSION TIME:288

COMPONENT RELIABILITY DATA TABLE

SUBSYSTEM COMPONENT	FAILURE RATE PER MILLION HRS	RELIABILITY FOR 288 HRS
INITIATING CHANNEL FOR FBEVAS, CREFAS, CPIAS	12.5	.996406
ACTUATING CHANNEL & RELAYS FOR FBEVAS, CREVAS, CPIAS	7.17	.997937
AC POWER SOURCE	40	.988546
DC POWER SOURCE	4	.998849
AC TO DC POWER SUPPLY	25	.992826
DC TO DC POWER SUPPLY	25	.992826
INITIATING CHANNEL FOR CREVIAS	15.8	.99546
ACTUATING CHANNEL FOR CREVIAS	7.87	.997736
LOP/LS MODULE		
A. TRIP SECTION	5.77	.99834
B. 2/4 AND OUTPUT	11.8	.996607
DGSS	11.6	.996665
ESF LOAD SEQUENCER	20.7	.994056

RELIABILITY BY SUBSYSTEM

SUBSYSTEM	RELIABILITY
POWER SUPPLY	.999846
FBEVAS	.999977
CREFAS	.999977
CPIAS	.999981
CREVIAS(SMCROA)	.999972
CREVIAS(HGCROA)	.999972
DGSS	.999988
LOSS OF POWER	.999987
LOAD SEQUENCER	.999963

TOTAL SYSTEM RELIABILITY FOR 288 HOUR MISSION TIME: .999977

MISSION TIME:336

COMPONENT RELIABILITY DATA TABLE

SUBSYSTEM COMPONENT	FAILURE RATE PER MILLION HRS	RELIABILITY FOR 336 HRS
INITIATING CHANNEL FOR FBEVAS, CREFAS, CPIAS	12.5	.995809
ACTUATING CHANNEL & RELAYS FOR FBEVAS, CREVAS, CPIAS	7.17	.997594
AC POWER SOURCE	40	.98665
DC POWER SOURCE	4	.998657
AC TO DC POWER SUPPLY	25	.991635
DC TO DC POWER SUPPLY	25	.991635
INITIATING CHANNEL FOR CREVIAS	15.8	.994705
ACTUATING CHANNEL FOR CREVIAS	7.87	.997359
LOP/LS MODULE		
A. TRIP SECTION	5.77	.998063
B. 2/4 AND OUTPUT	11.8	.996043
DGSS	11.6	.99611
ESF LOAD SEQUENCER	20.7	.993069

RELIABILITY BY SUBSYSTEM

SUBSYSTEM	RELIABILITY
POWER SUPPLY	.999791
FBEVAS	.999968
CREFAS	.999968
CPIAS	.999974
CREVIAS(SMCROA)	.999962
CREVIAS(HGCROA)	.999962
DGSS	.999984
LOSS OF POWER	.999983
LOAD SEQUENCER	.999949

TOTAL SYSTEM RELIABILITY FOR 336 HOUR MISSION TIME: .999969

MISSION TIME:384

COMPONENT RELIABILITY DATA TABLE

SUBSYSTEM COMPONENT	FAILURE RATE PER MILLION HRS	RELIABILITY FOR 384 HRS
INITIATING CHANNEL FOR FBEVAS, CREFAS, CPIAS	12.5	.995211
ACTUATING CHANNEL & RELAYS FOR FBEVAS, CREVAS, CPIAS	7.17	.99725
AC POWER SOURCE	40	.984757
DC POWER SOURCE	4	.998465
AC TO DC POWER SUPPLY	25	.990446
DC TO DC POWER SUPPLY	25	.990446
INITIATING CHANNEL FOR CREVIAS	15.8	.993951
ACTUATING CHANNEL FOR CREVIAS	7.87	.996982
LOP/LS MODULE		
A. TRIP SECTION	5.77	.997787
B. 2/4 AND OUTPUT	11.8	.995479
DGSS	11.6	.995556
ESF LOAD SEQUENCER	20.7	.992083

RELIABILITY BY SUBSYSTEM

SUBSYSTEM	RELIABILITY
POWER SUPPLY	.999727
FBEVAS	.999958
CREFAS	.999958
CPIAS	.999965
CREVIAS(SMCROA)	.999949
CREVIAS(HGCROA)	.999949
DGSS	.999979
LOSS OF POWER	.999977
LOAD SEQUENCER	.999933

TOTAL SYSTEM RELIABILITY FOR 384 HOUR MISSION TIME: .999959

MISSION TIME:432

COMPONENT RELIABILITY DATA TABLE

SUBSYSTEM COMPONENT	FAILURE RATE PER MILLION HRS	RELIABILITY FOR 432 HRS
INITIATING CHANNEL FOR FBEVAS, CREFAS, CPIAS	12.5	.994614
ACTUATING CHANNEL & RELAYS FOR FBEVAS, CREVAS, CPIAS	7.17	.996907
AC POWER SOURCE	40	.982868
DC POWER SOURCE	4	.998273
AC TO DC POWER SUPPLY	25	.989258
DC TO DC POWER SUPPLY	25	.989258
INITIATING CHANNEL FOR CREVIAS	15.8	.993198
ACTUATING CHANNEL FOR CREVIAS	7.87	.996606
LOP/LS MODULE		
A. TRIP SECTION	5.77	.99751
B. 2/4 AND OUTPUT	11.8	.994915
DGSS	11.6	.995001
ESF LOAD SEQUENCER	20.7	.991097

RELIABILITY BY SUBSYSTEM

SUBSYSTEM	RELIABILITY
POWER SUPPLY	.999655
FBEVAS	.999946
CREFAS	.999946
CPIAS	.999956
CREVIAS(SMCROA)	.999935
CREVIAS(HGCROA)	.999935
DGSS	.999973
LOSS OF POWER	.999971
LOAD SEQUENCER	.999914

TOTAL SYSTEM RELIABILITY FOR 432 HOUR MISSION TIME: .999947

MISSION TIME:480

COMPONENT RELIABILITY DATA TABLE

SUBSYSTEM COMPONENT	FAILURE RATE PER MILLION HRS	RELIABILITY FOR 480 HRS
INITIATING CHANNEL FOR FBEVAS, CREFAS, CPIAS	12.5	.994018
ACTUATING CHANNEL & RELAYS FOR FBEVAS, CREVAS, CPIAS	7.17	.996564
AC POWER SOURCE	40	.980983
DC POWER SOURCE	4	.998082
AC TO DC POWER SUPPLY	25	.988072
DC TO DC POWER SUPPLY	25	.988072
INITIATING CHANNEL FOR CREVIAS	15.8	.992445
ACTUATING CHANNEL FOR CREVIAS	7.87	.996229
LOP/LS MODULE		
A. TRIP SECTION	5.77	.997234
B. 2/4 AND OUTPUT	11.8	.994352
DGSS	11.6	.994447
ESF LOAD SEQUENCER	20.7	.990113

RELIABILITY BY SUBSYSTEM

SUBSYSTEM	RELIABILITY
POWER SUPPLY	.999575
FBEVAS	.999933
CREFAS	.999933
CPIAS	.999944
CREVIAS(SMCROA)	.999919
CREVIAS(HGCROA)	.999919
DGSS	.999967
LOSS OF POWER	.999963
LOAD SEQUENCER	.999893

TOTAL SYSTEM RELIABILITY FOR 480 HOUR MISSION TIME: .999934

MISSION TIME:528

COMPONENT RELIABILITY DATA TABLE

SUBSYSTEM COMPONENT	FAILURE RATE PER MILLION HRS	RELIABILITY FOR 528 HRS
INITIATING CHANNEL FOR FBEVAS, CREFAS, CPIAS	12.5	.993422
ACTUATING CHANNEL & RELAYS FOR FBEVAS, CREVAS, CPIAS	7.17	.996221
AC POWER SOURCE	40	.979101
DC POWER SOURCE	4	.99789
AC TO DC POWER SUPPLY	25	.986887
DC TO DC POWER SUPPLY	25	.986887
INITIATING CHANNEL FOR CREVIAS	15.8	.991692
ACTUATING CHANNEL FOR CREVIAS	7.87	.995853
LOP/LS MODULE		
A. TRIP SECTION	5.77	.996958
B. 2/4 AND OUTPUT	11.8	.993789
DGSS	11.6	.993894
ESF LOAD SEQUENCER	20.7	.98913

RELIABILITY BY SUBSYSTEM

SUBSYSTEM	RELIABILITY
POWER SUPPLY	.999487
FBEVAS	.999917
CREFAS	.999917
CPIAS	.999932
CREVIAS(SMCROA)	.999901
CREVIAS(HGCROA)	.999901
DGSS	.999959
LOSS OF POWER	.999955
LOAD SEQUENCER	.99987

TOTAL SYSTEM RELIABILITY FOR 528 HOUR MISSION TIME: .999919

MISSION TIME:576

COMPONENT RELIABILITY DATA TABLE

SUBSYSTEM COMPONENT	FAILURE RATE PER MILLION HRS	RELIABILITY FOR 576 HRS
INITIATING CHANNEL FOR FBEVAS, CREFAS, CPIAS	12.5	.992826
ACTUATING CHANNEL & RELAYS FOR FBEVAS, CREVAS, CPIAS	7.17	.995879
AC POWER SOURCE	40	.977223
DC POWER SOURCE	4	.997699
AC TO DC POWER SUPPLY	25	.985703
DC TO DC POWER SUPPLY	25	.985703
INITIATING CHANNEL FOR CREVIAS	15.8	.99094
ACTUATING CHANNEL FOR CREVIAS	7.87	.995477
LOP/LS MODULE		
A. TRIP SECTION	5.77	.996682
B. 2/4 AND OUTPUT	11.8	.993226
DGSS	11.6	.993341
ESF LOAD SEQUENCER	20.7	.988148

RELIABILITY BY SUBSYSTEM

SUBSYSTEM	RELIABILITY
POWER SUPPLY	.999391
FBEVAS	.999901
CREFAS	.999901
CPIAS	.999918
CREVIAS(SMCROA)	.999881
CREVIAS(HGCROA)	.999881
DGSS	.999951
LOSS OF POWER	.999946
LOAD SEQUENCER	.999843

TOTAL SYSTEM RELIABILITY FOR 576 HOUR MISSION TIME: .999903

MISSION TIME:624

COMPONENT RELIABILITY DATA TABLE

SUBSYSTEM COMPONENT	FAILURE RATE PER MILLION HRS	RELIABILITY FOR 624 HRS
INITIATING CHANNEL FOR FBEVAS, CREFAS, CPIAS	12.5	.99223
ACTUATING CHANNEL & RELAYS FOR FBEVAS, CREVAS, CPIAS	7.17	.995536
AC POWER SOURCE	40	.975349
DC POWER SOURCE	4	.997507
AC TO DC POWER SUPPLY	25	.984521
DC TO DC POWER SUPPLY	25	.984521
INITIATING CHANNEL FOR CREVIAS	15.8	.990189
ACTUATING CHANNEL FOR CREVIAS	7.87	.995101
LOP/LS MODULE		
A. TRIP SECTION	5.77	.996406
B. 2/4 AND OUTPUT	11.8	.992664
DGSS	11.6	.992788
ESF LOAD SEQUENCER	20.7	.987166

RELIABILITY BY SUBSYSTEM

SUBSYSTEM	RELIABILITY
POWER SUPPLY	.999287
FBEVAS	.999882
CREFAS	.999882
CPIAS	.999902
CREVIAS(SMCROA)	.999858
CREVIAS(HGCROA)	.999858
DGSS	.999942
LOSS OF POWER	.999935
LOAD SEQUENCER	.999815

TOTAL SYSTEM RELIABILITY FOR 624 HOUR MISSION TIME: .999884

MISSION TIME:672

COMPONENT RELIABILITY DATA TABLE

SUBSYSTEM COMPONENT	FAILURE RATE PER MILLION HRS	RELIABILITY FOR 672 HRS
INITIATING CHANNEL FOR FBEVAS, CREFAS, CPIAS	12.5	.991635
ACTUATING CHANNEL & RELAYS FOR FBEVAS, CREVAS, CPIAS	7.17	.995193
AC POWER SOURCE	40	.973478
DC POWER SOURCE	4	.997315
AC TO DC POWER SUPPLY	25	.98334
DC TO DC POWER SUPPLY	25	.98334
INITIATING CHANNEL FOR CREVIAS	15.8	.989438
ACTUATING CHANNEL FOR CREVIAS	7.87	.994725
LOP/LS MODULE		
A. TRIP SECTION	5.77	.99613
B. 2/4 AND OUTPUT	11.8	.992102
DGSS	11.6	.992235
ESF LOAD SEQUENCER	20.7	.986186

RELIABILITY BY SUBSYSTEM

SUBSYSTEM	RELIABILITY
POWER SUPPLY	.999175
FBEVAS	.999862
CREFAS	.999862
CPIAS	.999885
CREVIAS(SMCROA)	.999834
CREVIAS(HGCROA)	.999834
DGSS	.999933
LOSS OF POWER	.999924
LOAD SEQUENCER	.999784

TOTAL SYSTEM RELIABILITY FOR 672 HOUR MISSION TIME: .999865

MISSION TIME:720

COMPONENT RELIABILITY DATA TABLE

SUBSYSTEM COMPONENT	FAILURE RATE PER MILLION HRS	RELIABILITY FOR 720 HRS
INITIATING CHANNEL FOR FBEVAS, CREFAS, CPIAS	12.5	.99104
ACTUATING CHANNEL & RELAYS FOR FBEVAS, CREVAS, CPIAS	7.17	.994851
AC POWER SOURCE	40	.971611
DC POWER SOURCE	4	.997124
AC TO DC POWER SUPPLY	25	.982161
DC TO DC POWER SUPPLY	25	.982161
INITIATING CHANNEL FOR CREVIAS	15.8	.988688
ACTUATING CHANNEL FOR CREVIAS	7.87	.99435
LOF/LS MODULE		
A. TRIP SECTION	5.77	.995854
B. 2/4 AND OUTPUT	11.8	.99154
DGSS	11.6	.991683
ESF LOAD SEQUENCER	20.7	.985206

RELIABILITY BY SUBSYSTEM

SUBSYSTEM	RELIABILITY
POWER SUPPLY	.999055
FBEVAS	.999839
CREFAS	.999839
CPIAS	.999866
CREVIAS(SMCROA)	.999808
CREVIAS(HGCROA)	.999808
DGSS	.999922
LOSS OF POWER	.999912
LOAD SEQUENCER	.99975

TOTAL SYSTEM RELIABILITY FOR 720 HOUR MISSION TIME: .999843

MISSION TIME:768

COMPONENT RELIABILITY DATA TABLE

SUBSYSTEM COMPONENT	FAILURE RATE PER MILLION HRS	RELIABILITY FOR 768 HRS
INITIATING CHANNEL FOR FBEVAS, CREFAS, CPIAS	12.5	.990446
ACTUATING CHANNEL & RELAYS FOR FBEVAS, CREVAS, CPIAS	7.17	.994509
AC POWER SOURCE	40	.969747
DC POWER SOURCE	4	.996933
AC TO DC POWER SUPPLY	25	.980983
DC TO DC POWER SUPPLY	25	.980983
INITIATING CHANNEL FOR CREVIAS	15.8	.987939
ACTUATING CHANNEL FOR CREVIAS	7.87	.993974
LOF/LS MODULE		
A. TRIP SECTION	5.77	.995578
B. 2/4 AND OUTPUT	11.8	.990979
DGSS	11.6	.991131
ESF LOAD SEQUENCER	20.7	.984228

RELIABILITY BY SUBSYSTEM

SUBSYSTEM	RELIABILITY
POWER SUPPLY	.998927
FBEVAS	.999815
CREFAS	.999815
CPIAS	.999845
CREVIAS(SMCROA)	.999779
CREVIAS(HGCROA)	.999779
DGSS	.999911
LOSS OF POWER	.999898
LOAD SEQUENCER	.999713

TOTAL SYSTEM RELIABILITY FOR 768 HOUR MISSION TIME: .99982

MISSION TIME:816

COMPONENT RELIABILITY DATA TABLE

SUBSYSTEM COMPONENT	FAILURE RATE PER MILLION HRS	RELIABILITY FOR 816 HRS
INITIATING CHANNEL FOR FBEVAS, CREFAS, CPIAS	12.5	.989852
ACTUATING CHANNEL & RELAYS FOR FBEVAS, CREVAS, CPIAS	7.17	.994166
AC POWER SOURCE	40	.967887
DC POWER SOURCE	4	.996741
AC TO DC POWER SUPPLY	25	.979807
DC TO DC POWER SUPPLY	25	.979807
INITIATING CHANNEL FOR CREVIAS	15.8	.98719
ACTUATING CHANNEL FOR CREVIAS	7.87	.993599
LOF/LS MODULE		
A. TRIP SECTION	5.77	.995303
B. 2/4 AND OUTPUT	11.8	.990417
DGSS	11.6	.990579
ESF LOAD SEQUENCER	20.7	.983251

RELIABILITY BY SUBSYSTEM

SUBSYSTEM	RELIABILITY
POWER SUPPLY	.998792
FBEVAS	.999789
CREFAS	.999789
CPIAS	.999823
CREVIAS(SMCROA)	.999748
CREVIAS(HGCROA)	.999748
DGSS	.999899
LOSS OF POWER	.999884
LOAD SEQUENCER	.999674

TOTAL SYSTEM RELIABILITY FOR 816 HOUR MISSION TIME: .999794

MISSION TIME:864

COMPONENT RELIABILITY DATA TABLE

SUBSYSTEM COMPONENT	FAILURE RATE PER MILLION HRS	RELIABILITY FOR 864 HRS
INITIATING CHANNEL FOR FBEVAS, CREFAS, CPIAS	12.5	.989258
ACTUATING CHANNEL & RELAYS FOR FBEVAS, CREVAS, CPIAS	7.17	.993824
AC POWER SOURCE	40	.96603
DC POWER SOURCE	4	.99655
AC TO DC POWER SUPPLY	25	.978632
DC TO DC POWER SUPPLY	25	.978632
INITIATING CHANNEL FOR CREVIAS	15.8	.986441
ACTUATING CHANNEL FOR CREVIAS	7.87	.993223
LOP/LS MODULE		
A. TRIP SECTION	5.77	.995027
B. 2/4 AND OUTPUT	11.8	.989857
DGSS	11.6	.990028
ESF LOAD SEQUENCER	20.7	.982274

RELIABILITY BY SUBSYSTEM

SUBSYSTEM	RELIABILITY
POWER SUPPLY	.998649
FBEVAS	.999761
CREFAS	.999761
CPIAS	.9998
CREVIAS(SMCROA)	.999714
CREVIAS(HGCROA)	.999714
DGSS	.999885
LOSS OF POWER	.999868
LOAD SEQUENCER	.999632

TOTAL SYSTEM RELIABILITY FOR 864 HOUR MISSION TIME: .999767

MISSION TIME:912

COMPONENT RELIABILITY DATA TABLE

SUBSYSTEM COMPONENT	FAILURE RATE PER MILLION HRS	RELIABILITY FOR 912 HRS
INITIATING CHANNEL FOR FBEVAS, CREFAS, CPIAS	12.5	.988665
ACTUATING CHANNEL & RELAYS FOR FBEVAS, CREVAS, CPIAS	7.17	.993482
AC POWER SOURCE	40	.964177
DC POWER SOURCE	4	.996359
AC TO DC POWER SUPPLY	25	.977458
DC TO DC POWER SUPPLY	25	.977458
INITIATING CHANNEL FOR CREVIAS	15.8	.985694
ACTUATING CHANNEL FOR CREVIAS	7.87	.992848
LOP/LS MODULE		
A. TRIP SECTION	5.77	.994752
B. 2/4 AND OUTPUT	11.8	.989296
DGSS	11.6	.989477
ESF LOAD SEQUENCER	20.7	.981299

RELIABILITY BY SUBSYSTEM

SUBSYSTEM	RELIABILITY
POWER SUPPLY	.998498
FBEVAS	.999731
CREFAS	.999731
CPIAS	.999774
CREVIAS(SMCROA)	.999679
CREVIAS(HGCROA)	.999679
DGSS	.999871
LOSS OF POWER	.999851
LOAD SEQUENCER	.999587

TOTAL SYSTEM RELIABILITY FOR 912 HOUR MISSION TIME: .999738

MISSION TIME:960

COMPONENT RELIABILITY DATA TABLE

SUBSYSTEM COMPONENT	FAILURE RATE PER MILLION HRS	RELIABILITY FOR 960 HRS
INITIATING CHANNEL FOR FBEVAS, CREFAS, CPIAS	12.5	.988072
ACTUATING CHANNEL & RELAYS FOR FBEVAS, CREVAS, CPIAS	7.17	.99314
AC POWER SOURCE	40	.962328
DC POWER SOURCE	4	.996167
AC TO DC POWER SUPPLY	25	.976286
DC TO DC POWER SUPPLY	25	.976286
INITIATING CHANNEL FOR CREVIAS	15.8	.984947
ACTUATING CHANNEL FOR CREVIAS	7.87	.992473
LOP/LS MODULE		
A. TRIP SECTION	5.77	.994476
B. 2/4 AND OUTPUT	11.8	.988736
DGSS	11.6	.988926
ESF LOAD SEQUENCER	20.7	.980324

RELIABILITY BY SUBSYSTEM

SUBSYSTEM	RELIABILITY
POWER SUPPLY	.998339
FBEVAS	.999699
CREFAS	.999699
CPIAS	.999746
CREVIAS(SMCROA)	.99964
CREVIAS(HGCROA)	.99964
DGSS	.999856
LOSS OF POWER	.999833
LOAD SEQUENCER	.999539

TOTAL SYSTEM RELIABILITY FOR 960 HOUR MISSION TIME: .999707

APPENDIX C

COMPUTER RELIABILITY COMPUTATION

FOR

PALO VERDE NUCLEAR GENERATING STATION
BALANCE OF PLANT ENGINEERED SAFETY
FEATURES ACTUATION SYSTEM

BECHTEL JOB 10407
PURCHASE ORDER 10407-13-JM-104

DECEMBER 12, 1978

PROJECT NO. 2192

GENERAL ATOMIC COMPANY
ELECTRONIC SYSTEMS DIVISION
P O BOX 81608
SAN DIEGO, CALIFORNIA 92138

MISSION TIME:0

COMPONENT RELIABILITY DATA TABLE

SUBSYSTEM COMPONENT	FAILURE RATE PER MILLION HRS	RELIABILITY FOR 0 HRS
INITIATING CHANNEL FOR FBEVAS, CREFAS, CPIAS	12.5	1
ACTUATING CHANNEL & RELAYS FOR FBEVAS, CREVAS, CPIAS	7.17	1
AC POWER SOURCE	40	1
DC POWER SOURCE	4	1
AC TO DC POWER SUPPLY	25	1
DC TO DC POWER SUPPLY	25	1
INITIATING CHANNEL FOR CREVIAS	15.8	1
ACTUATING CHANNEL FOR CREVIAS	7.87	1
LOP/LS MODULE		
A. TRIP SECTION	5.77	1
B. 2/4 AND OUTPUT	11.8	1
DGSS	11.6	1
ESF LOAD SEQUENCER	20.7	1

RELIABILITY BY SUBSYSTEM

SUBSYSTEM	RELIABILITY
POWER SUPPLY	1
FBEVAS	1
CREFAS	1
CPIAS	1
CREVIAS(SMCROA)	1
CREVIAS(HGCROA)	1
DGSS	1
LOSS OF POWER	1
LOAD SEQUENCER	1

TOTAL SYSTEM RELIABILITY FOR 0 HOUR MISSION TIME: 1

COMPONENT RELIABILITY DATA TABLE

SUBSYSTEM COMPONENT	FAILURE RATE PER MILLION HRS	RELIABILITY FOR 5.00000E-02 HRS
INITIATING CHANNEL FOR FBEVAS, CREFAS, CPIAS	12.5	.999999
ACTUATING CHANNEL & RELAYS FOR FBEVAS, CREVAS, CPIAS	7.17	1
AC POWER SOURCE	40	.999998
DC POWER SOURCE	4	1
AC TO DC POWER SUPPLY	25	.999999
DC TO DC POWER SUPPLY	25	.999999
INITIATING CHANNEL FOR CREVIAS	15.8	.999999
ACTUATING CHANNEL FOR CREVIAS	7.87	1
LOP/LS MODULE		
A. TRIP SECTION	5.77	1
B. 2/4 AND OUTPUT	11.8	.999999
DGSS	11.6	.999999
ESF LOAD SEQUENCER	20.7	.999999

RELIABILITY BY SUBSYSTEM

SUBSYSTEM	RELIABILITY
POWER SUPPLY	1
FBEVAS	1
CREFAS	1
CPIAS	1
CREVIAS(SMCROA)	1
CREVIAS(HGCROA)	1
DGSS	1
LOSS OF POWER	1
LOAD SEQUENCER	1

TOTAL SYSTEM RELIABILITY FOR 5.00000E-02 HOUR MISSION TIME: 1

COMPONENT RELIABILITY DATA TABLE

SUBSYSTEM COMPONENT	FAILURE RATE PER MILLION HRS	RELIABILITY FOR .1 HRS
INITIATING CHANNEL FOR FBEVAS, CREFAS, CPIAS	12.5	.999999
ACTUATING CHANNEL & RELAYS FOR FBEVAS, CREVAS, CPIAS	7.17	.999999
AC POWER SOURCE	40	.999996
DC POWER SOURCE	4	1
AC TO DC POWER SUPPLY	25	.999997
DC TO DC POWER SUPPLY	25	.999997
INITIATING CHANNEL FOR CREVIAS	15.8	.999998
ACTUATING CHANNEL FOR CREVIAS	7.87	.999999
LOP/LS MODULE		
A. TRIP SECTION	5.77	.999999
B. 2/4 AND OUTPUT	11.8	.999999
DGSS	11.6	.999999
ESF LOAD SEQUENCER	20.7	.999998

RELIABILITY BY SUBSYSTEM

SUBSYSTEM	RELIABILITY
POWER SUPPLY	1
FBEVAS	1
CREFAS	1
CPIAS	1
CREVIAS(SMCROA)	1
CREVIAS(HGCROA)	1
DGSS	1
LOSS OF POWER	1
LOAD SEQUENCER	1

TOTAL SYSTEM RELIABILITY FOR .1 HOUR MISSION TIME: 1

MISSION TIME: .199219

COMPONENT RELIABILITY DATA TABLE

SUBSYSTEM COMPONENT	FAILURE RATE PER MILLION HRS	RELIABILITY FOR .2 HRS
INITIATING CHANNEL FOR FBEVAS, CREFAS, CPIAS	12.5	.999997
ACTUATING CHANNEL & RELAYS FOR FBEVAS, CREVAS, CPIAS	7.17	.999999
AC POWER SOURCE	40	.999992
DC POWER SOURCE	4	.999999
AC TO DC POWER SUPPLY	25	.999995
DC TO DC POWER SUPPLY	25	.999995
INITIATING CHANNEL FOR CREVIAS	15.8	.999997
ACTUATING CHANNEL FOR CREVIAS	7.87	.999998
LOP/LS MODULE		
A. TRIP SECTION	5.77	.999999
B. 2/4 AND OUTPUT	11.8	.999998
DGSS	11.6	.999998
ESF LOAD SEQUENCER	20.7	.999996

RELIABILITY BY SUBSYSTEM

SUBSYSTEM	RELIABILITY
POWER SUPPLY	1
FBEVAS	1
CREFAS	1
CPIAS	1
CREVIAS(SMCROA)	1
CREVIAS(HGCROA)	1
DGSS	1
LOSS OF POWER	1
LOAD SEQUENCER	1

TOTAL SYSTEM RELIABILITY FOR .2 HOUR MISSION TIME: 1

MISSION TIME: .298828

COMPONENT RELIABILITY DATA TABLE

SUBSYSTEM COMPONENT	FAILURE RATE PER MILLION HRS	RELIABILITY FOR .3 HRS
INITIATING CHANNEL FOR FBEVAS, CREFAS, CPIAS	12.5	.999996
ACTUATING CHANNEL & RELAYS FOR FBEVAS, CREVAS, CPIAS	7.17	.999998
AC POWER SOURCE	40	.999988
DC POWER SOURCE	4	.999999
AC TO DC POWER SUPPLY	25	.999992
DC TO DC POWER SUPPLY	25	.999992
INITIATING CHANNEL FOR CREVIAS	15.8	.999995
ACTUATING CHANNEL FOR CREVIAS	7.87	.999998
LOP/LS MODULE		
A. TRIP SECTION	5.77	.999998
B. 2/4 AND OUTPUT	11.8	.999996
DGSS	11.6	.999997
ESF LOAD SEQUENCER	20.7	.999994

RELIABILITY BY SUBSYSTEM

SUBSYSTEM	RELIABILITY
POWER SUPPLY	1
FBEVAS	1
CREFAS	1
CPIAS	1
CREVIAS(SMCROA)	1
CREVIAS(HGCROA)	1
DGSS	1
LOSS OF POWER	1
LOAD SEQUENCER	1

TOTAL SYSTEM RELIABILITY FOR .3 HOUR MISSION TIME: 1

MISSION TIME: .398438

COMPONENT RELIABILITY DATA TABLE

SUBSYSTEM COMPONENT	FAILURE RATE PER MILLION HRS	RELIABILITY FOR .4 HRS
INITIATING CHANNEL FOR FBEVAS, CREFAS, CPIAS	12.5	.999995
ACTUATING CHANNEL & RELAYS FOR FBEVAS, CREVAS, CPIAS	7.17	.999997
AC POWER SOURCE	40	.999984
DC POWER SOURCE	4	.999998
AC TO DC POWER SUPPLY	25	.99999
DC TO DC POWER SUPPLY	25	.99999
INITIATING CHANNEL FOR CREVIAS	15.8	.999994
ACTUATING CHANNEL FOR CREVIAS	7.87	.999997
LOP/LS MODULE		
A. TRIP SECTION	5.77	.999998
B. 2/4 AND OUTPUT	11.8	.999995
DGSS	11.6	.999995
ESF LOAD SEQUENCER	20.7	.999992

RELIABILITY BY SUBSYSTEM

SUBSYSTEM	RELIABILITY
POWER SUPPLY	1
FBEVAS	1
CREFAS	1
CPIAS	1
CREVIAS(SMCROA)	1
CREVIAS(HGCROA)	1
DGSS	1
LOSS OF POWER	1
LOAD SEQUENCER	1

TOTAL SYSTEM RELIABILITY FOR .4 HOUR MISSION TIME: 1

MISSION TIME:.5

COMPONENT RELIABILITY DATA TABLE

SUBSYSTEM COMPONENT	FAILURE RATE PER MILLION HRS	RELIABILITY FOR .5 HRS
INITIATING CHANNEL FOR FBEVAS, CREFAS, CPIAS	12.5	.999994
ACTUATING CHANNEL & RELAYS FOR FBEVAS, CREVAS, CPIAS	7.17	.999996
AC POWER SOURCE	40	.99998
DC POWER SOURCE	4	.999998
AC TO DC POWER SUPPLY	25	.999987
DC TO DC POWER SUPPLY	25	.999987
INITIATING CHANNEL FOR CREVIAS	15.8	.999992
ACTUATING CHANNEL FOR CREVIAS	7.87	.999996
LOP/LS MODULE		
A. TRIP SECTION	5.77	.999997
B. 2/4 AND OUTPUT	11.8	.999974
DGSS	11.6	.999994
ESF LOAD SEQUENCER	20.7	.99999

RELIABILITY BY SUBSYSTEM

SUBSYSTEM	RELIABILITY
POWER SUPPLY	1
FBEVAS	1
CREFAS	1
CPIAS	1
CREVIAS(SMCROA)	1
CREVIAS(HGCROA)	1
DGSS	1
LOSS OF POWER	1
LOAD SEQUENCER	1

TOTAL SYSTEM RELIABILITY FOR .5 HOUR MISSION TIME: 1

MISSION TIME:.597656

COMPONENT RELIABILITY DATA TABLE

SUBSYSTEM COMPONENT	FAILURE RATE PER MILLION HRS	RELIABILITY FOR .6 HRS
INITIATING CHANNEL FOR FBEVAS, CREFAS, CPIAS	12.5	.999992
ACTUATING CHANNEL & RELAYS FOR FBEVAS, CREVAS, CPIAS	7.17	.999996
AC POWER SOURCE	40	.999976
DC POWER SOURCE	4	.999998
AC TO DC POWER SUPPLY	25	.999985
DC TO DC POWER SUPPLY	25	.999985
INITIATING CHANNEL FOR CREVIAS	15.8	.99999
ACTUATING CHANNEL FOR CREVIAS	7.87	.999995
LOP/LS MODULE		
A. TRIP SECTION	5.77	.999997
B. 2/4 AND OUTPUT	11.8	.999993
DGSS	11.6	.999993
ESF LOAD SEQUENCER	20.7	.999988

RELIABILITY BY SUBSYSTEM

SUBSYSTEM	RELIABILITY
POWER SUPPLY	1
FBEVAS	1
CREFAS	1
CPIAS	1
CREVIAS(SMCROA)	1
CREVIAS(HGCROA)	1
DGSS	1
LOSS OF POWER	1
LOAD SEQUENCER	1

TOTAL SYSTEM RELIABILITY FOR .6 HOUR MISSION TIME: 1

MISSION TIME: .796875

COMPONENT RELIABILITY DATA TABLE

SUBSYSTEM COMPONENT	FAILURE RATE PER MILLION HRS	RELIABILITY FOR .8 HRS
INITIATING CHANNEL FOR FBEVAS, CREFAS, CPIAS	12.5	.99999
ACTUATING CHANNEL & RELAYS FOR FBEVAS, CREVAS, CPIAS	7.17	.999994
AC POWER SOURCE	40	.999968
DC POWER SOURCE	4	.999997
AC TO DC POWER SUPPLY	25	.99998
DC TO DC POWER SUPPLY	25	.99998
INITIATING CHANNEL FOR CREVIAS	15.8	.999987
ACTUATING CHANNEL FOR CREVIAS	7.87	.999994
LOP/LS MODULE		
A. TRIP SECTION	5.77	.999995
B. 2/4 AND OUTPUT	11.8	.999991
DGSS	11.6	.999991
ESF LOAD SEQUENCER	20.7	.999983

RELIABILITY BY SUBSYSTEM

SUBSYSTEM	RELIABILITY
POWER SUPPLY	1
FBEVAS	1
CREFAS	1
CPIAS	1
CREVIAS(SMCROA)	1
CREVIAS(HGCROA)	1
DGSS	1
LOSS OF POWER	1
LOAD SEQUENCER	1

TOTAL SYSTEM RELIABILITY FOR .8 HOUR MISSION TIME: 1

MISSION TIME:1

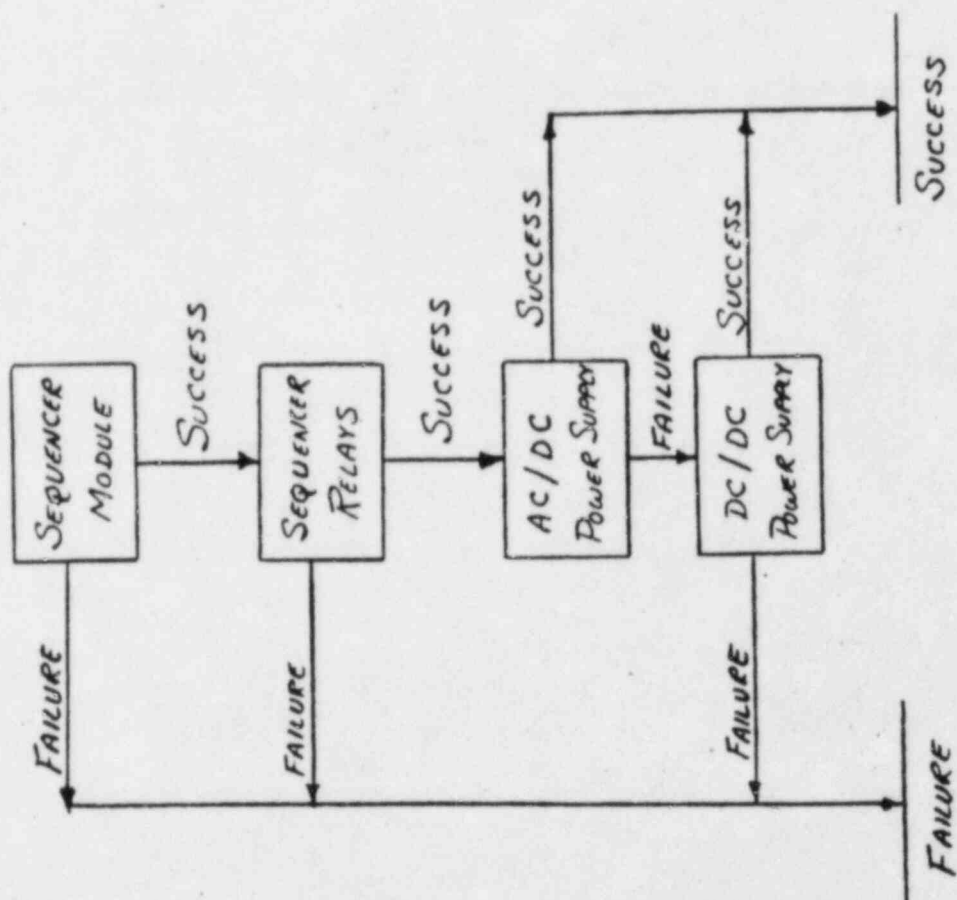
COMPONENT RELIABILITY DATA TABLE

SUBSYSTEM COMPONENT	FAILURE RATE PER MILLION HRS	RELIABILITY FOR 1 HRS
INITIATING CHANNEL FOR FBEVAS, CREFAS, CPIAS	12.5	.999987
ACTUATING CHANNEL & RELAYS FOR FBEVAS, CREVAS, CPIAS	7.17	.999993
AC POWER SOURCE	40	.999996
DC POWER SOURCE	4	.999996
AC TO DC POWER SUPPLY	25	.999975
DC TO DC POWER SUPPLY	25	.999975
INITIATING CHANNEL FOR CREVIAS	15.8	.999984
ACTUATING CHANNEL FOR CREVIAS	7.87	.999992
LOP/LS MODULE		
A. TRIP SECTION	5.77	.999994
B. 2/4 AND OUTPUT	11.8	.999988
DGSS	11.6	.999988
ESF LOAD SEQUENCER	20.7	.999979

RELIABILITY BY SUBSYSTEM

SUBSYSTEM	RELIABILITY
POWER SUPPLY	1
FBEVAS	1
CREFAS	1
CPIAS	1
CREVIAS(SMCROA)	1
CREVIAS(HGCROA)	1
DGSS	1
LOSS OF POWER	1
LOAD SEQUENCER	1

TOTAL SYSTEM RELIABILITY FOR 1 HOUR MISSION TIME: 1



RELIABILITY BLOCK DIAGRAM
SEQUENCER

RELIABILITY CALCULATIONS

• RELIABILITY OF SEQUENCER

$$R = P_s (\text{SEQUENCER MODULE}) * \\ P_s (\text{SEQUENCER RELAYS}) * \\ [P_s (\text{AC/DC POWER SUPPLY}) + \\ (1 - P_s (\text{AC/DC POWER SUPPLY})) * \\ P_s (\text{DC/DC POWER SUPPLY})]$$

$$R = .99999897$$

$$(1 - R) = 1.03 \times 10^{-6}$$

$$P_s = \text{PROBABILITY OF SUCCESS} \\ = e^{-\lambda t}$$

$$\lambda = \text{FAILURE RATE DETERMINED BY MIL-HDBK-217A}$$

$$t = \text{ELAPSED TIME DURING AUTO TEST}$$

FOR 2 REDUNDANT TRAINS / UNIT

$$R = .999999999999894$$

$$(1 - R) = 1.06 \times 10^{-12}$$

AUTO TEST FUNCTION

OPERATIONAL DESCRIPTION

1. Scope

The ESF load sequencer for each logic train contains the necessary hardware and associated software programs stored in read only memory to determine that each functional channel within that train will respond to field initiated input contact action and that the ESF load sequencer in the opposite train is operative.

A. The Auto Test Function Does Not Check:

1. The Cross Logic Train Actuation Signal Operation - Response times dictated by specified signal filtering bandpass limit of 30Hz do not allow test pulses to propagate to the opposite train.
2. Actual Actuation Relay Contact Transfer - Only the relay drive current response is monitored.
3. Manually Initiated Actuation Inputs

2. Module Selection and Test Scheme

A. Address Select and Test Enable Bus

Each module has an address code associated with its position in the system (eg. FBEVAS-01, CREFAS-02, CPIAS-03, LOP/LG-04, CRVIAS-05, DOSS-06) which is set within the module via a mini-dip switch unit. As the module address select signal bus (4 lines) is strobed with each successive code, the selected module will admit test pulses (10 msec wide; 250 msec apart; 4 per test) which propagate through the logic and are sensed in such a way as to prepare a return signal to be sent back to the auto test function contained within the ESF load sequencer for interpretation.

The LOP/LS module requires an additional four lines (Test Enable) to interpret the module response to all possible two of four pairs.

B. Module Test Response Return Interpretation

As the modules are successively selected, the auto test features within the sequencer examines the test returns and active signals received from the modules and looks for a particular pattern based upon the system configuration and within the time frame of the test. The auto test feature is then able to determine if the module has passed or failed a test or if a field related (actual input) has been received. In the case of a failed test or an actual input, the auto test feature will cease operation.

C. Test Failure Indication

Each module contains a test indicator lamp that illuminates in a steady state while that module is under test. As the auto test feature strobes each module the test indication will appear to "walk" across the face of the bin assembly containing the modules. If the auto test feature determines an erroneous response, it will cause the test indicator on the module where the failure was detected to flash. The error may or may not be within that module dependent upon the system configuration and the position of the module in the test order (eg. if the FBEVAS module correctly responded to the test, yet a failure in the CREFAS module failed to provide its required automatic output - the auto test feature would flash the error indicator in the FBEVAS module). Further manual tests might be required to isolate the fault. When the auto test feature terminates testing under either an error detection or receipt of an actual input, the required auto test terminate (fail) annunciator contacts will transfer to the alarm state. During auto test operation the "auto test on" annunciator contacts are transferred.

D. Test Success Indication

As the modules are strobed into test by the module select bus (solid test indicator illumination), the test pulses propagating through the module actuation logic will cause the associated indicators to "flicker". As the module successfully completes its test, the next module in line is strobed and its actuation associated indicators "flicker", until all modules are tested including the ESF load sequencer itself.