Reactor Protection System

Chapter 10.1

B&W Cross-Training Course

R-326C

OBJECTIVES

1. State the purpose of the RPS.
2. Explain how the following design features are incorporated into the RPS:
   a. Single failure criterion
   b. Testability
   c. Equipment qualification (environment, power)
   d. Independence
   e. Redundancy
3. Given a list of Rx trip signals, explain the basis for each

OBJECTIVES

4. Describe the sequence of events that occur during a Rx trip from the sensor to the trip breaker, including the normal RPS logic.
5. Explain when the channel bypass and shutdown bypass features are used and what effects each have on the RPS, including any changes in RPS logic.
6. Describe the trip circuit breaker logic used to interrupt power to the CRDMs, and explain why failures in the rod control system do not affect the reactor trip capability.

Reactor Protection System

- Purpose – to protect the barriers that prevent the release of radioactive fission products to the general public during Anticipated Operational Occurrences (AOO).
- 10 CFR Part 50, Appendix A, defines an AOO as those conditions of normal operation which are expected to occur one of more times during the life of the plant & include:
  - Loss of RCS flow
  - Turbine trip
  - Isolation of main condenser
  - LOOP

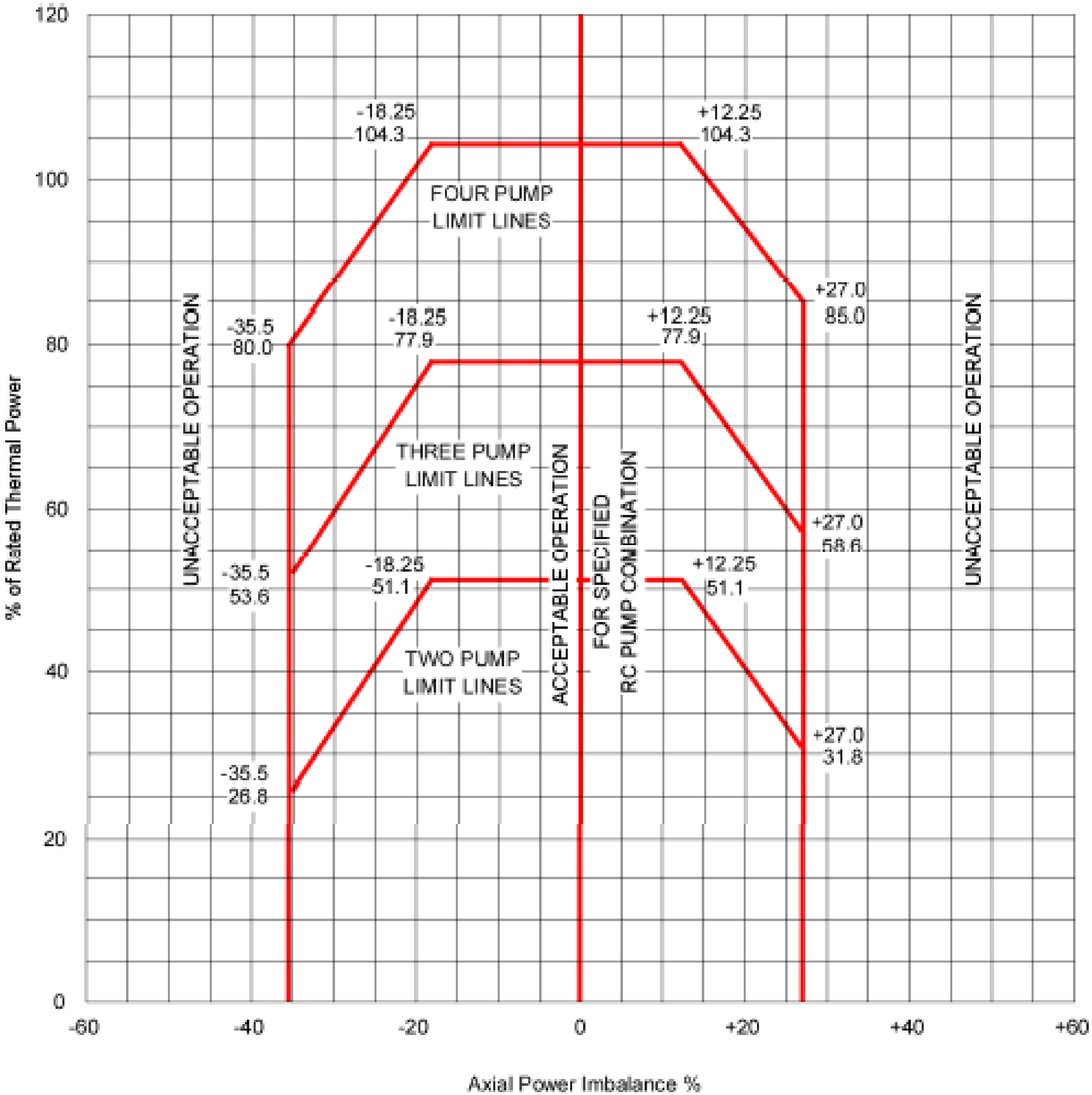
RPS (cont-1)

- TS Safety Limits ensure limits are not violated.
  - ❑Max RCS pressure,
  - ❑Max fuel centerline temperature,
  - ❑Minimum value for DNBR
- RPS ensures the Safety Limits are not exceeded and the barriers are protected.
- RPS prevents the Safety Limits from being exceeded by interrupting power to the control rod drives, allowing the rods to drop into the core.

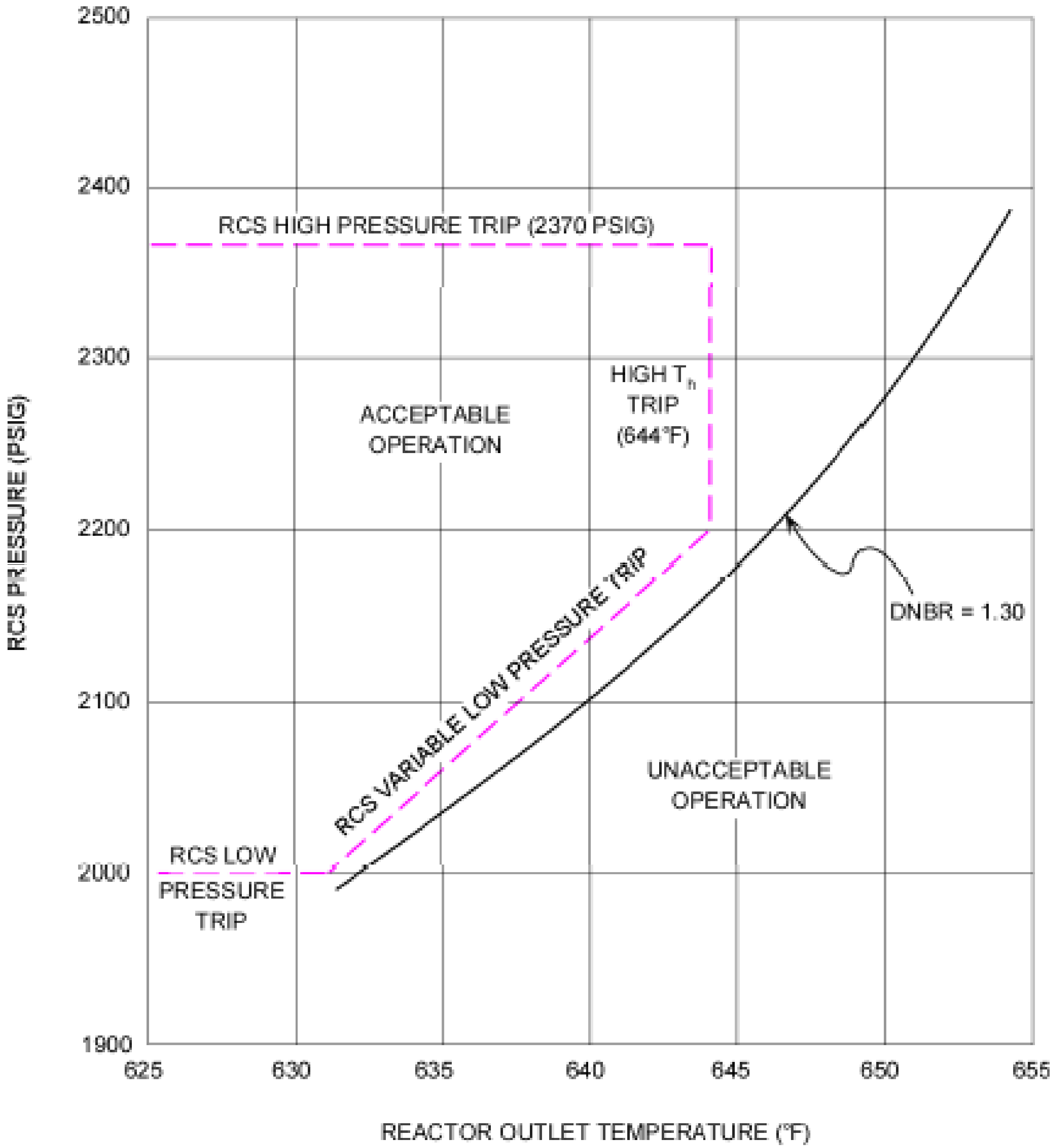
RPS (cont-2)

- Four independent, redundant channels.
- Logic: 2/4 channels sensing ANY trip signal.
- Different RPS designs for 205 FA & Davis-Besse (RPS-II).
- Differences:
  - ❑ Solid state devices, vice relays.
  - ❑ Optical isolators to separate Class 1E from non-1E.
  - ❑ Some trips replaced.

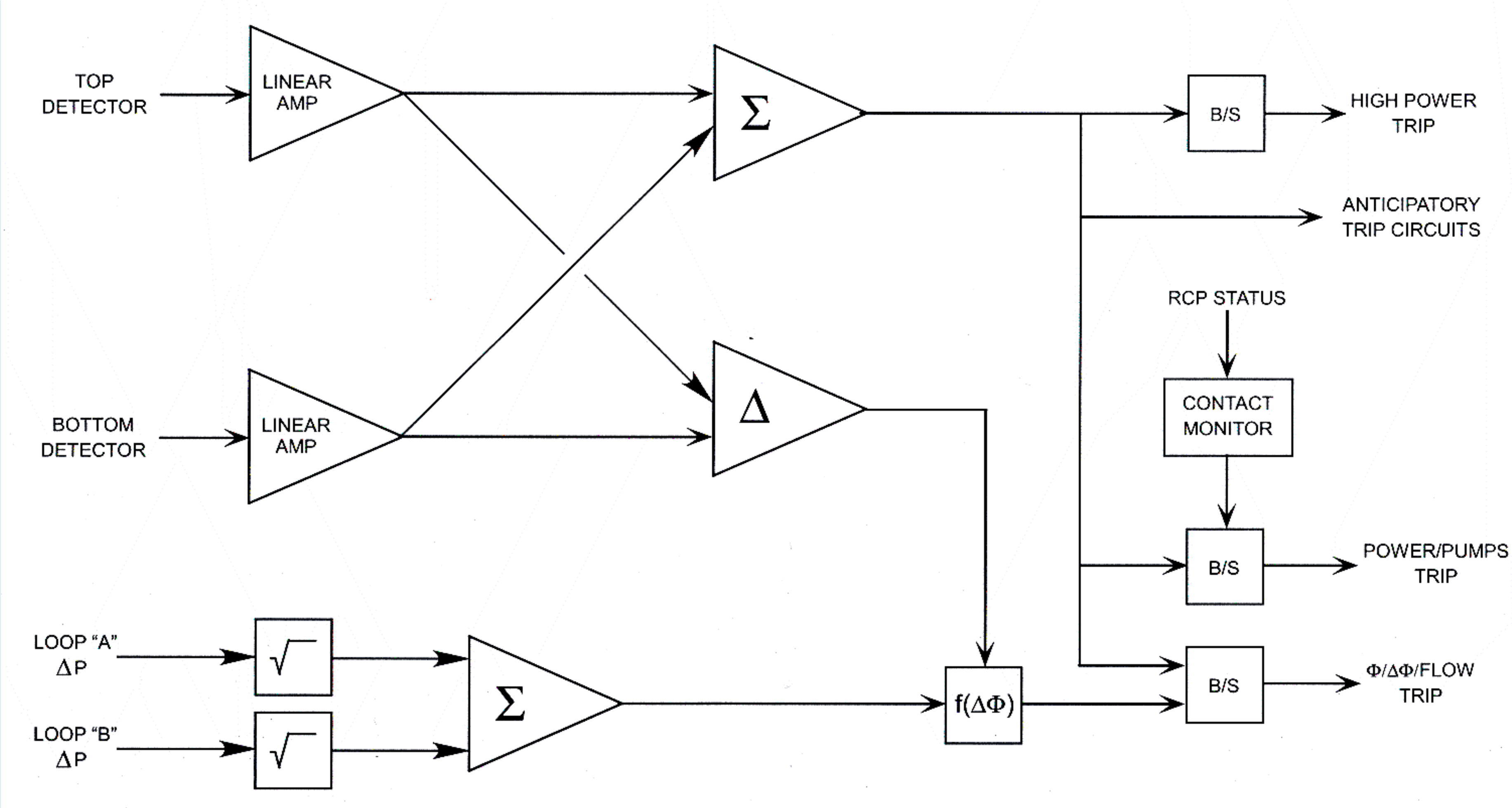
TABLE 10.1-1 REACTOR TRIP SUMMARY		
Trip	Setpoint	Protection Afforded
High Reactor Power	105.5%	1. Rapid reactivity excursions. 2. Upper bound for DNBR calculations.
Flux / Delta Flux / Flow ($\Phi/\Delta\Phi$/Flow)	See Figure 10.1-1	1. DNBR 2. kw/ft
Reactor Power to Pumps	2/2 - >125% * 1/2 - >125% * 1/1 - 55% 0/2 - Automatic Trip 0/1 - Automatic Trip 0/0 - Automatic Trip (* Protection provided by Flux / Delta Flux / Flow trip)	1. DNBR 2. Prevents single loop operation
High T_h	644°F	Backup for High Rx Power and High RCS Pressure trips.
High RCS Pressure	2370 psig	RCS boundary protection.
Low RCS Pressure	2000 psig	DNBR
Variable Low RCS Pressure	$15.4T_h$ - 7718 psig (T_h in °F)	DNBR
High Reactor Building Pressure	4 psig	Ensures that the reactor is shut down during accidents.
Anticipatory Loss of Main Feedwater	Loss of both MFPs above 10%	1. Loss of heat sink. 2. TMI-2 requirement.
Reactor Trip on Turbine Trip	Turbine trip above 40%	1. Loss of heat sink. 2. TMI-2 requirement.



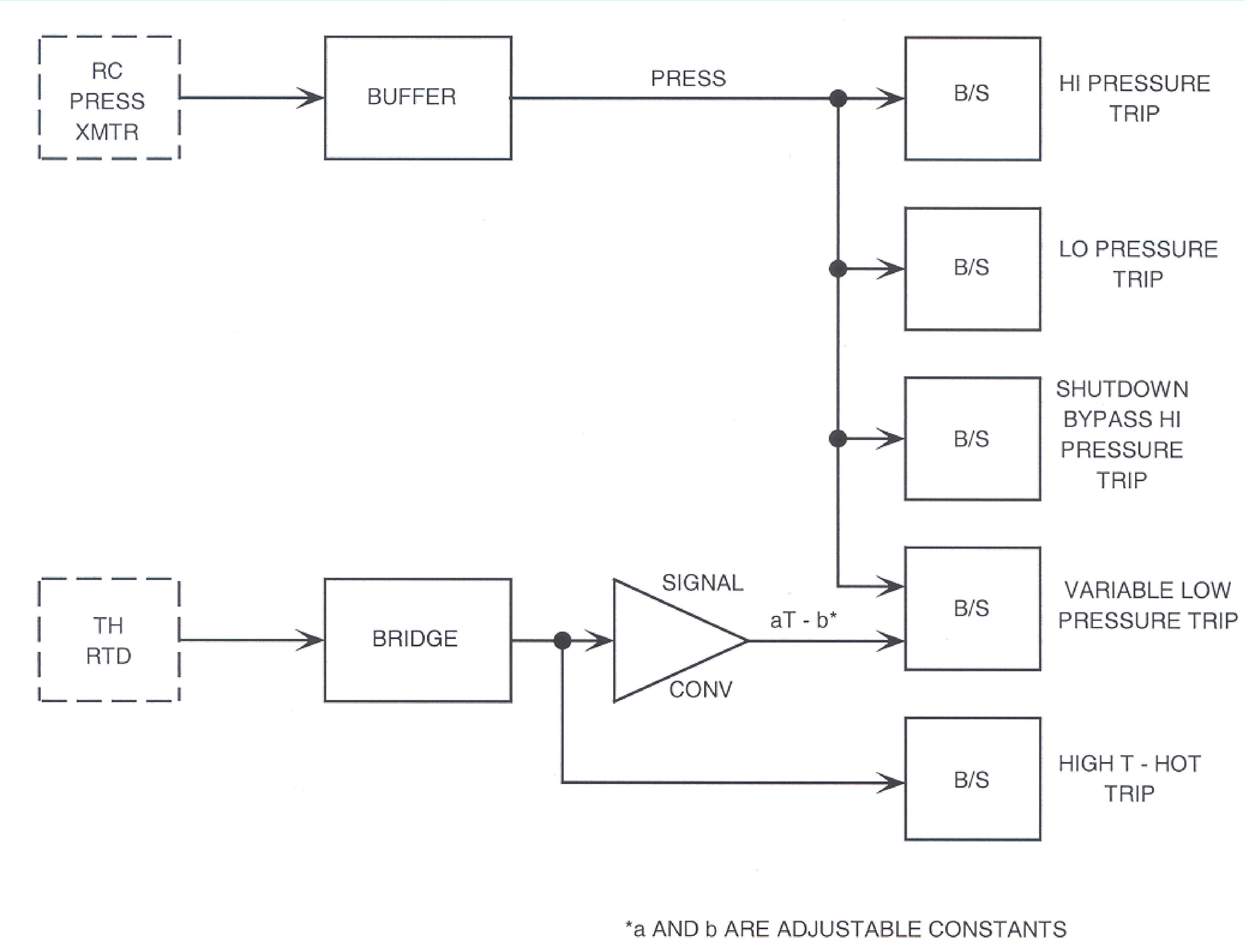
Flux/Delta Flux/Flow Trip Envelope
Fig. 10.1-1



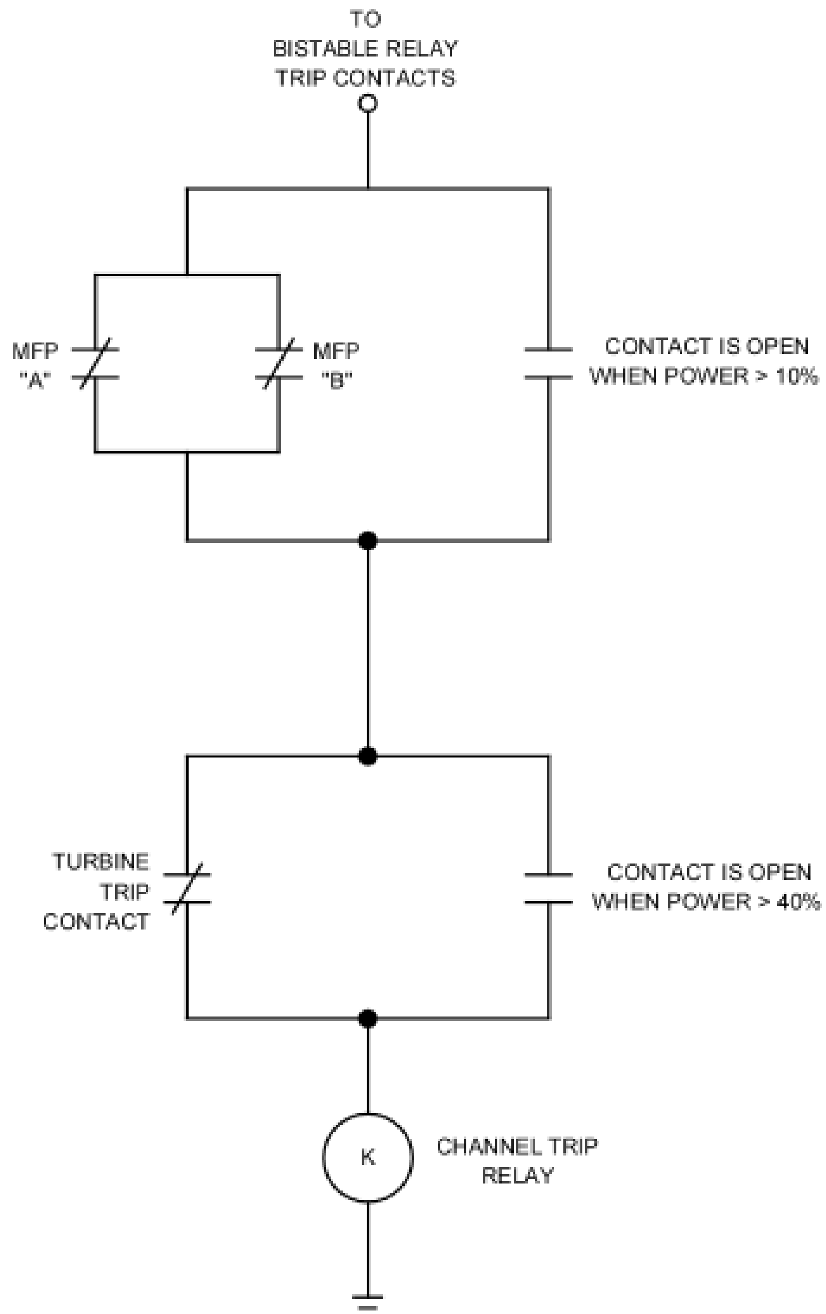
Pressure/Temp. Trip Envelope Fig. 10.1-2



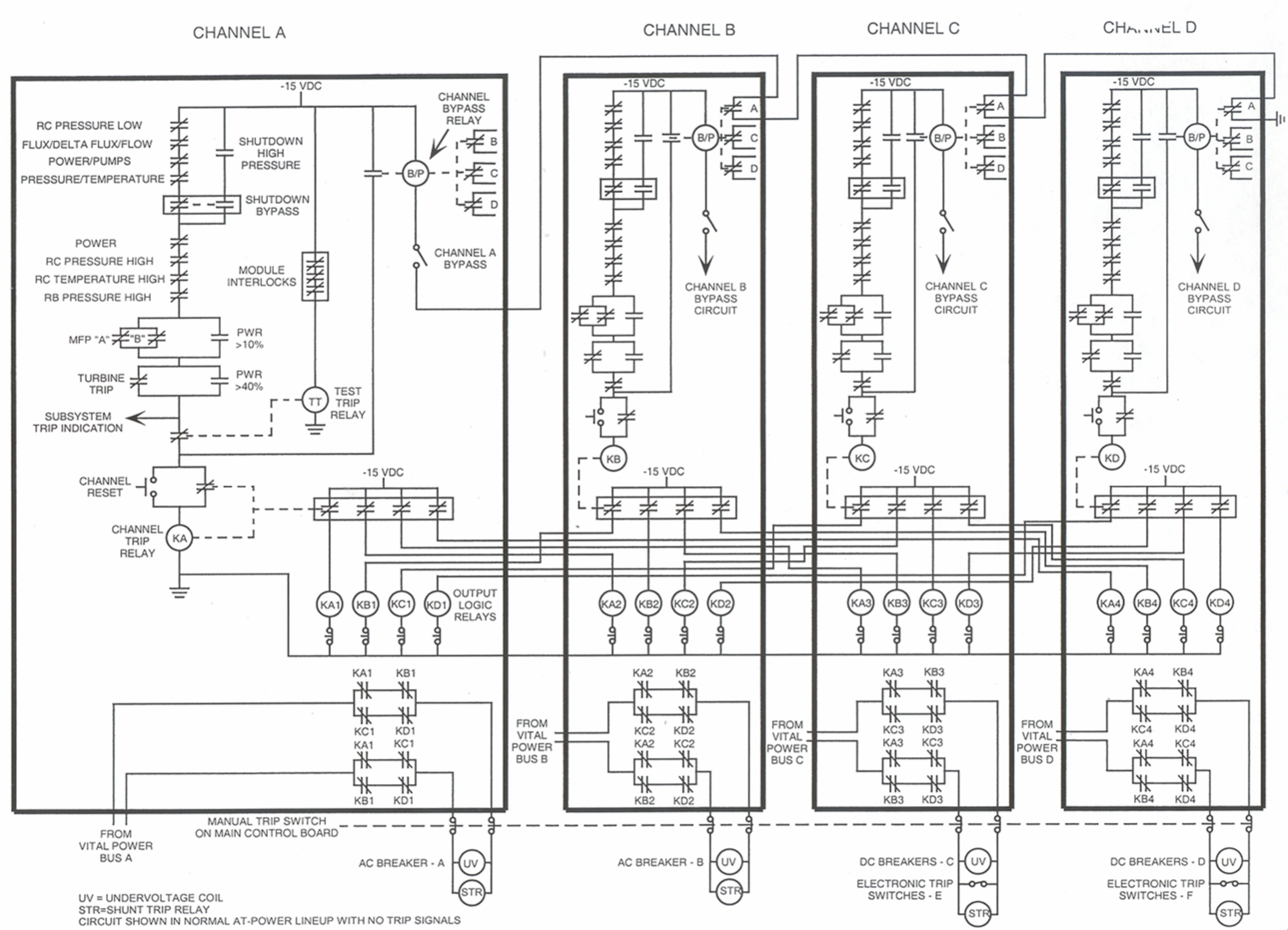
Excore Nuclear Instrumentation Inputs (Fig. 10.1-3)



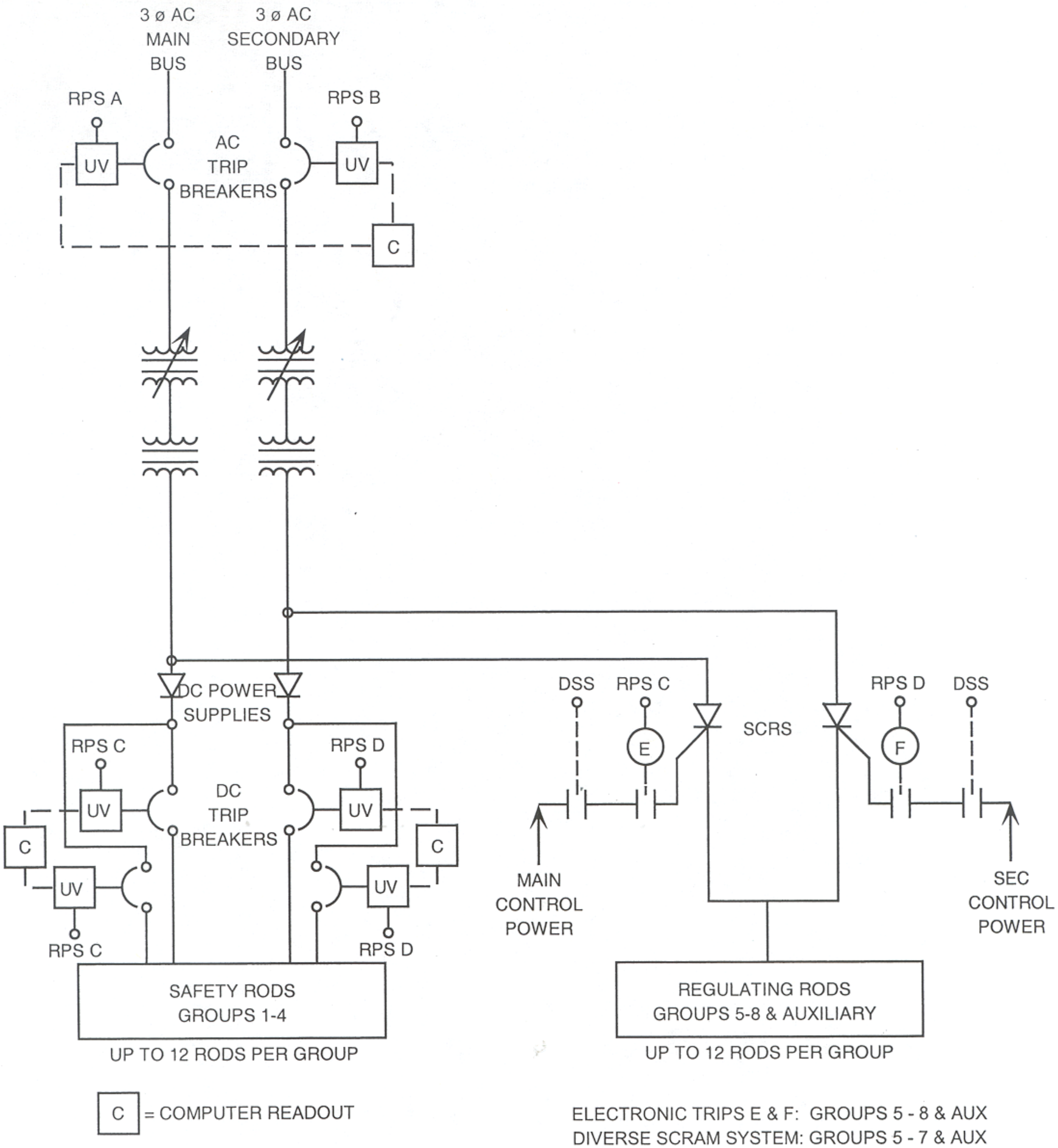
RPS Temperature and Pressure Inputs (Fig. 10.1-4)



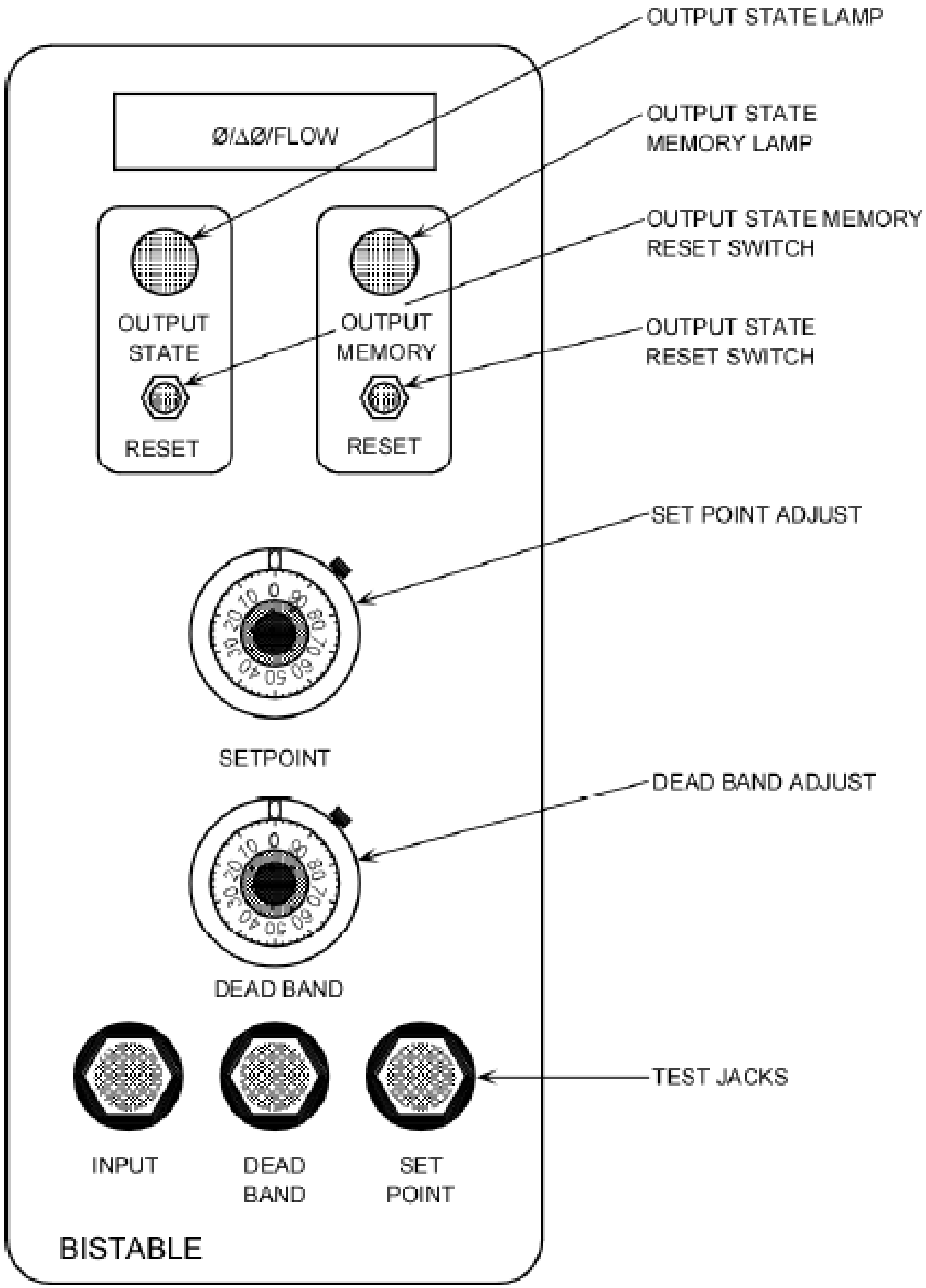
Anticipatory Trips Circuitry Fig. 10.1-5



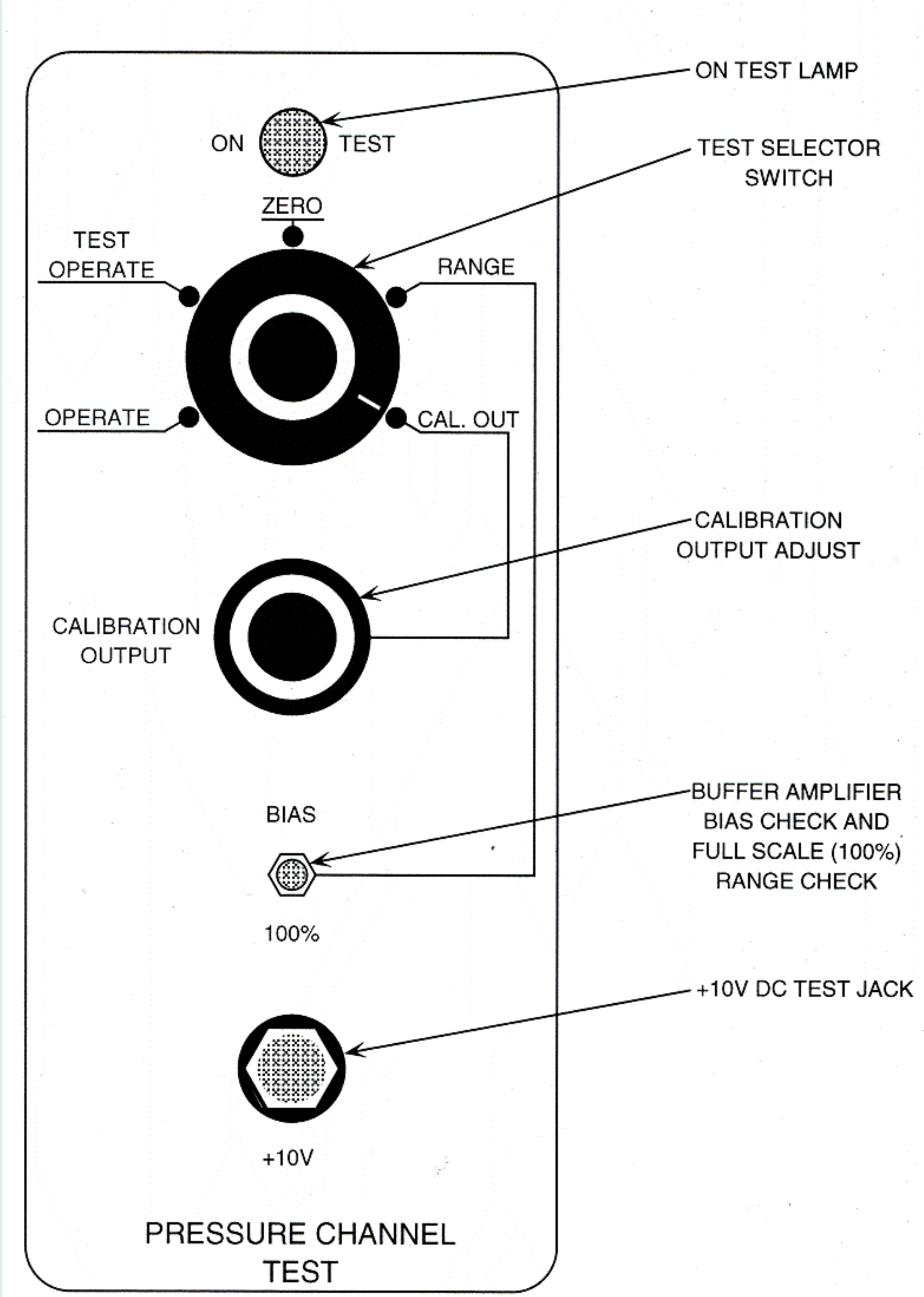
Reactor Protection System Channel Logic (Fig. 10.1-6)



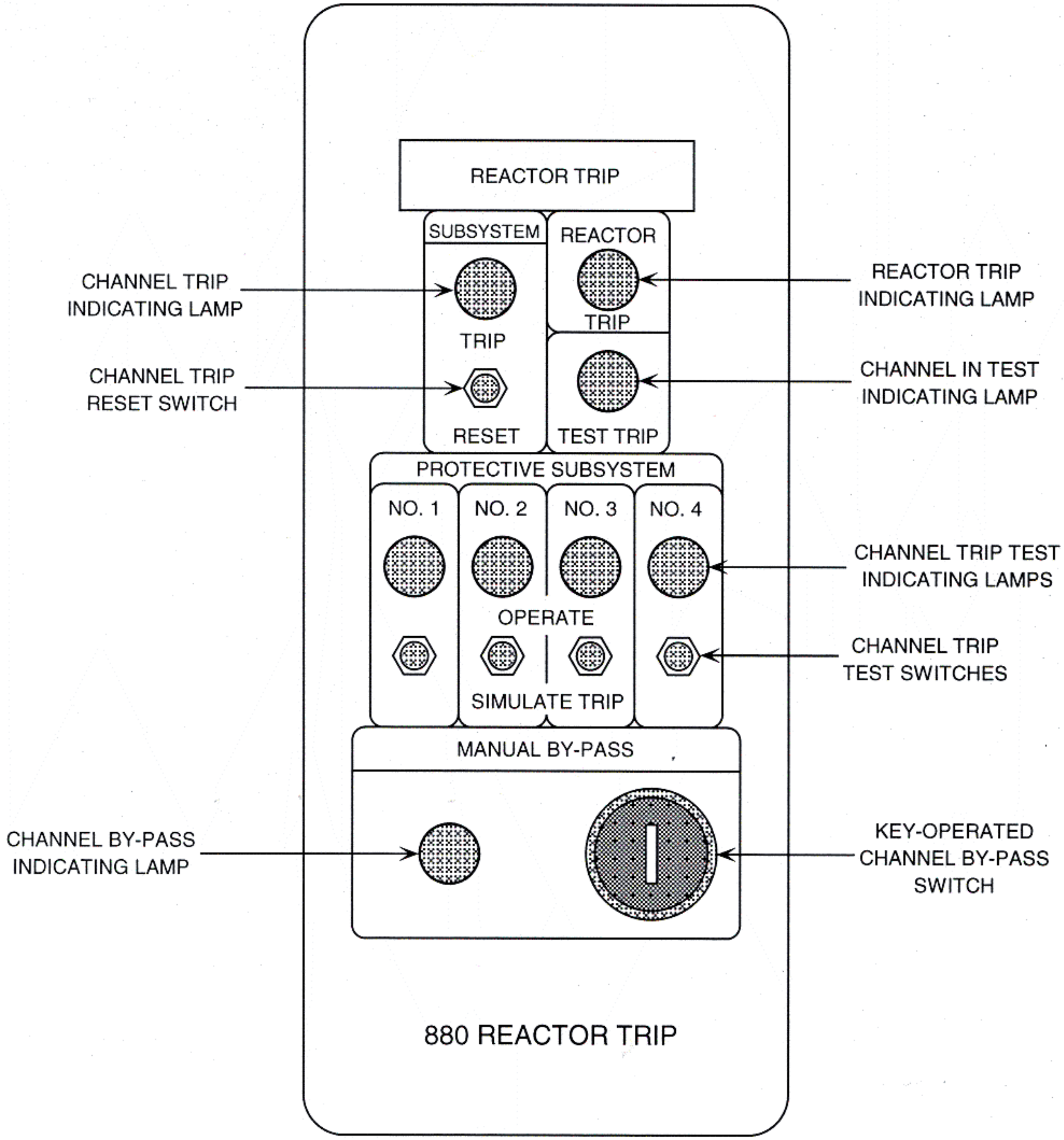
Reactor Trip Circuit Breakers Fig. 10.1-7



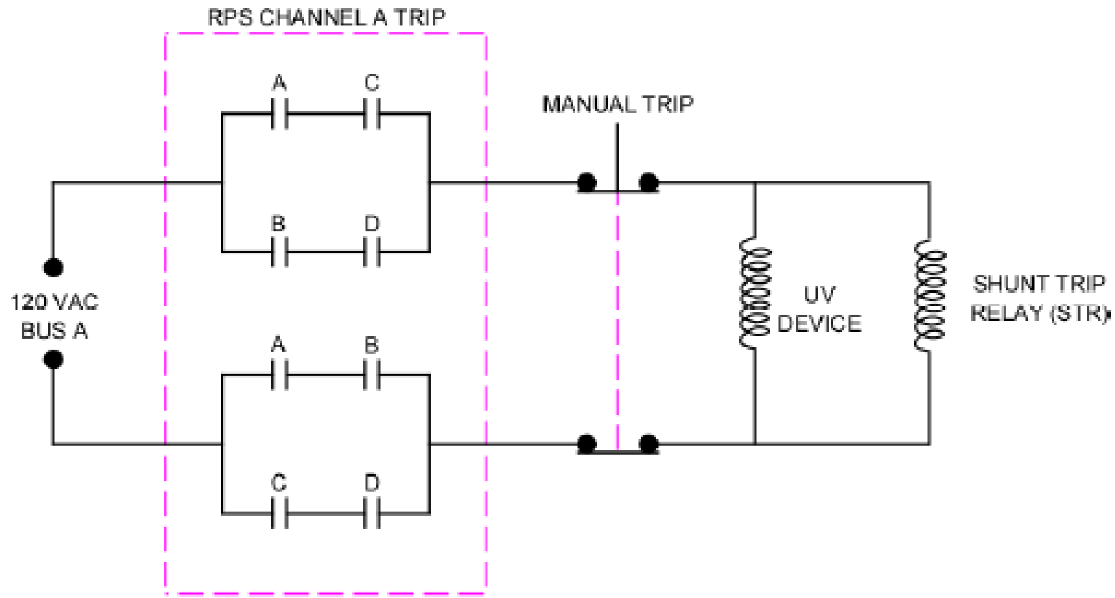
Bistable Module
Fig. 10.1-8

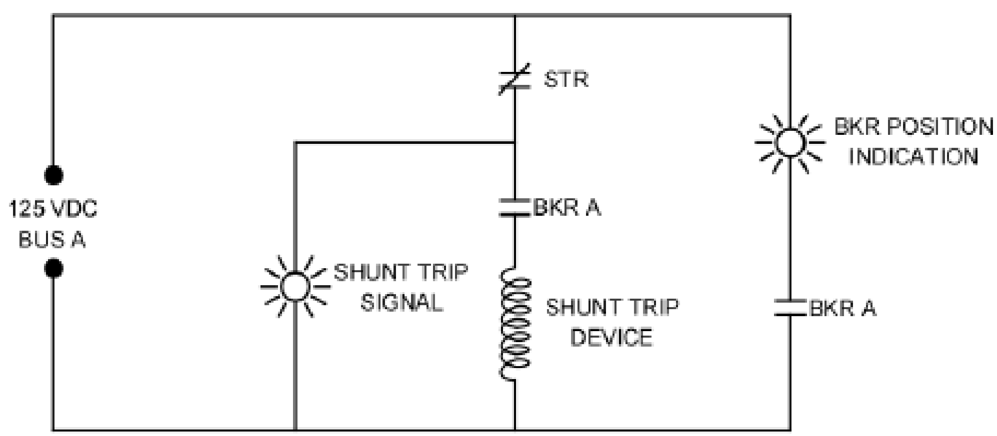


Channel Test
Module
Fig. 10.1-9



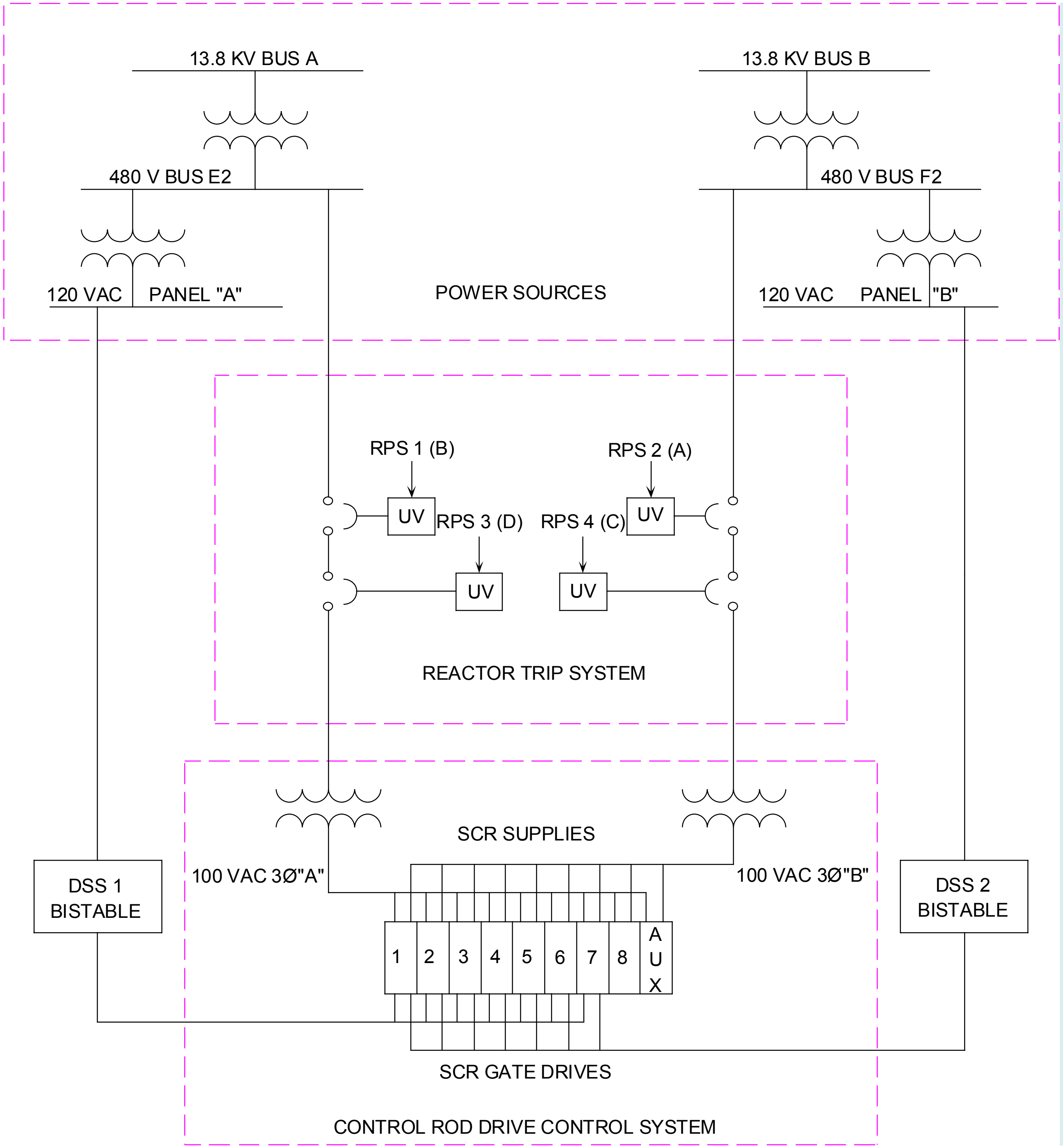
Reactor Trip Module Fig. 10.1-10





CIRCUIT SHOWN IN TRIPPED
(DEENERGIZED) CONDITION.

Shunt Trip Circuitry Fig. 10.1-11



Backup (Diverse) Scram System (Davis-Besse) Fig. 10.1-12