

General Electric Systems Technology Manual

Chapter 5.2

Intermediate Range Monitor System

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5.2 INTERMEDIATE RANGE MONITOR SYSTEM

Learning Objectives:

1. Recognize the purposes of the Intermediate Range Monitoring (IRM) System.
2. Recognize the purpose, function and operation of the following IRM major components:
 - a. Fission Chamber Detector
 - b. Range Switches
 - c. IRM Recorder
 - d. Trip Units
 - e. Bypass Switch
 - f. Detector Insert and Retract Mechanism
3. Recognize how the IRM system discriminates gamma flux from neutron flux.
4. Recognize the plant response to the following IRM signals, when the trips are bypassed and the reason for the trips:
 - a. Upscale High Trip
 - b. Upscale High Alarm
 - c. Downscale
 - d. Inoperable IRM
 - e. IRM detector not fully inserted
5. Recognize how the Intermediate Range Monitoring system interfaces with the following systems:
 - a. Reactor Protection System (Section 7.3)
 - b. Reactor Manual Control System (Section 7.1)
 - c. Average power range monitor system (Section 5.4)
 - d. Source Range Monitoring System (Section 5.1)

5.2.1 Introduction

The purposes of the Intermediate Range Monitoring (IRM) System are to:

- provide neutron flux indications from the upper portion of the source range to the lower portion of the power range
- provide scram signals to RPS to preserve the integrity of the fuel cladding
- provide rod block signals to the RMCS to preserve the integrity of the fuel cladding

The functional classification of the IRM System is that of a safety related system.

The IRM System consists of eight independent channels. Each IRM channel includes:

- a miniature fission detector
- electronic signal conditioning equipment
- readout equipment
- trip units
- a mechanical retraction mechanism

The eight fission chamber detectors are located at different radial core locations as shown in Figure 5.2-1.

The fission chamber detector signal is received by the voltage preamplifier. The preamplifier amplifies the detector signal and selects the correct frequency. The preamplifier signal is then sent to the control room. The amplifier, attenuator and mean square analog units condition the detector signal for use by the trip units and indicators.

5.2.2 Component Description

The major components of the IRM system are shown in Figure 5.2-2 and are discussed in the following paragraphs. Several components in the IRM System are similar to components in the SRM System.

5.2.2.1 Detector

The detectors used for the IRM channels are basically the same as the SRM detectors discussed in Section 5.1. The IRM detectors have the following differences:

- a lower argon pressure
- a lower uranium content
- a closer spacing between the cathode and anode

The closer spacing permits operation at higher thermal neutron flux levels with an operating voltage of 100 volts. As with the SRM detectors, the IRM detectors are retractable to preserve detector life. The IRM detectors are withdrawn when overlap is achieved with the Average Power Range Monitoring (APRM) System.

5.2.2.2 Detector Insert and Retract Mechanism

The IRM detector insert and retract mechanisms are identical to the SRM detector insert and retract mechanisms discussed in Section 5.1.

5.2.2.3 Voltage Preamplifier

The voltage preamplifier conditions the signal from the detector for input to the IRM electronics drawer. It converts the varying DC signal to an AC voltage signal and

selectively amplifies the signal. High voltage is supplied to the fission chamber detector through the voltage preamplifier. This high voltage signal comes from a power supply in the IRM electronics drawer in the control room. A filter in series with the high voltage supply reduces signal loss. In addition the filter provides isolation of the detector output signal from the power supply.

Two independent channels of amplification are used in the voltage preamplifier. These independent channels of amplification operate one at a time. This allows optimization of the preamplifier response. This optimization ensures that the output of the preamplifier is representative of actual reactor power. The range selector switches control the gain and bandwidth response of the preamplifier. The range selector switches are discussed in section 5.2.2.5.

5.2.2.4 Amplifier and Attenuation Unit

The AC signal from the voltage preamplifier is applied to the amplifier and attenuator unit in the IRM drawer. This unit provides six discrete gain ranges by switching the amount of attenuation in the signal path. The attenuation is selected so that there will be a factor of 10 output difference between alternate IRM ranges. If an IRM channel is reading 40 on range 1 it will read 4 on range 3 and 0.4 on range 5. If an IRM channel is reading 100 on range 6 it will read 10 on range 8 and 1.0 on range 10. Each setting of the range switch closes a set of contacts in the preamplifier and in the amplifier and attenuator module. These contacts are closed by outputs from the diode logic matrix. The input signal is routed from one of the two amplifier stages in the preamplifier through one of six attenuation paths. With the range switch on range 1, the preamplifier signal is applied to the amplifier stage with no attenuation. With the range switch set to range 2, the preamplifier signal is attenuated by a factor of 1.78. Successively larger values of attenuation are switched into the signal path from ranges 3 through 6. For ranges 7 through 10, the preamplifier input signal is applied from the second amplifier stage. No attenuation and attenuation ratios of 1.78, 3.16, and 5.62 are switched into the signal path. The combination of six attenuation ratios and two amplifier gain ranges makes for 12 ranges of measurement. As only 10 ranges are used a mechanical stop on the range switch prevents switch movement above range 10.

5.2.2.5 Diode Logic Matrix

The range switch position determines the output of the diode logic matrix. The diode logic matrix has two outputs. The first one controls the contacts in the preamplifier frequency section. The second one controls the amount of attenuation in the amplifier attenuator. The diode logic matrix controls the detector signal conditioning and attenuation before the signal reaches the operator's indication.

5.2.2.6 Inverter

The inverter is located between the amplifier and attenuator unit output and the mean square analog unit input. The inverter conditions the amplifier and attenuator output signal for use by the mean square analog unit. The inverter (Figure 5.2-3) module amplifies the input signal and produces two equal amplitude outputs of opposite polarity. The inverter ensures the mean square analog circuit will always receive a positive input signal.

5.2.2.7 Mean Square Analog Unit

The mean square analog unit (Figure 5.2-3) produces an analog signal directly proportional to the core neutron flux. The mean square analog unit receives two input signals. One signal is from the inverter and the second signal is from the amplifier and attenuator unit. A squaring circuit squares both input signals to produce a positive polarity output signal. As the neutron signal from the detector is much larger than the gamma signal it will receive the largest amplification when squared. Squaring both the neutron and gamma signals from the detector makes the gamma signal so small that it can be disregarded. The averaging circuit receives the signal from the squaring circuit and produces the mean (average) of this squared signal. The mean value is then sent to the operational amplifier.

5.2.2.8 Operational Amplifier

The operational amplifier provides the required output to drive the displays and trip units. Individual IRM displays are provided on the control room front panel recorders shared with the APRMs. Indications are also displayed on the associated IRM drawers in the control room back panels. The even IRM ranges (2, 4, 6, 8, and 10) utilize the 0-125% scale, while the odd ranges use the 0-40 scale.

5.2.2.9 Trip Units

The trip units used by the IRM channels are identical to those used by the SRMs, The IRM channel trip setpoints are listed in Table 5.2-1.

5.2.2.10 Bypass Switch

The RPS system (Section 7.3) IRM inputs are bypassed whenever the associated IRM bypass switch is placed in that detector position. The switch arrangement ensures only one IRM channel for each RPS division can be bypassed at a time. IRM channels A, C, E, and G have one bypass switch and provide trip inputs to RPS channel A. IRM channels B, D, F, and H have a second bypass switch and provide trip inputs to RPS channel B.

The bypass switches also bypass the rod withdrawal block inputs to the Reactor Manual Control System (Section 7.1).

5.2.3 System Features and Interfaces

A short discussion of system features and the interfaces this system has with other plant systems is given in the following paragraphs.

5.2.3.1 Rod Blocks and Scrams

The IRM system provides rod blocks and scrams to prevent fuel damage. These trips, along with their bypasses, are listed in Table 5.2-1.

5.2.3.2 IRM Recorders and Display Lights

The eight (8) IRM channels are displayed on four (4) two pen recorders on panel 603. The IRM's share these recorders with the APRM and RBM channels. Selection of which input is displayed is through the use of the select switches shown in Figure 5.2-6. Each IRM channel also has indications displayed on an IRM instrument drawer shown in Figure 5.2-5.

Each IRM channel has a group of lights associated with various trip functions listed in Table 5.2-1. These are located on panel 603 above the IRM range switches and on the IRM instrument drawer.

5.2.3.3 Operation During Startup

During reactor startup and the approach to criticality reactor power is monitored by the SRM system. When the SRM count rate is between 10^4 and 10^5 cps, the IRM channels should be on scale on range one. When the IRMs are on scale the SRM detectors are incrementally withdrawn maintaining their count rate between 10^2 and 10^5 cps. As reactor power approaches 75/125 of scale, the operator places the IRM range switch on the next higher range. The IRM readings should be maintained between 25/125 and 75/125 to avoid rod withdraw blocks (upscale or downscale). In the intermediate range the reactor power, although displayed on a linear scale (0-125), is increasing exponentially. This results in the indication appearing to accelerate on the upper end of the scale with a constant reactor period. On range 8 of the IRMs the APRM system indication begins to come on scale. Once the APRMs are well on scale (5-10% power) the reactor mode switch is placed in the run position. The IRM detectors are then fully withdrawn from the core region.

5.2.3.4 System Interfaces

The interfaces this system has with other plant systems are discussed in the following paragraphs.

Reactor Protection System (Section 7.3)

The RPS receives scram signals for IRM Upscale Hi and INOP from the IRM System.

Reactor Manual Control System (Section 7.1)

The RMC System receives rod block signals for IRM Hi, INOP, detector not fully inserted and downscale from the IRM System.

Emergency Distribution System (Section 9.2)

The Emergency Distribution System supplies power to operate the IRM detector drive mechanism.

Source Range Monitoring System (Section 5.1)

The SRM System receives signals from IRM range switch position. These signals automatically bypass the SRM rod blocks.

5.2.4 Summary

The purposes of the Intermediate Range Monitoring (IRM) System are to;

- provide neutron flux indications from the upper portion of the source range to the lower portion of the power range
- provide scram signals to RPS to preserve the integrity of the fuel cladding
- provide rod block signals to the RMCS to preserve the integrity of the fuel cladding

The IRM System consists of eight independent channels. Each IRM channel includes;

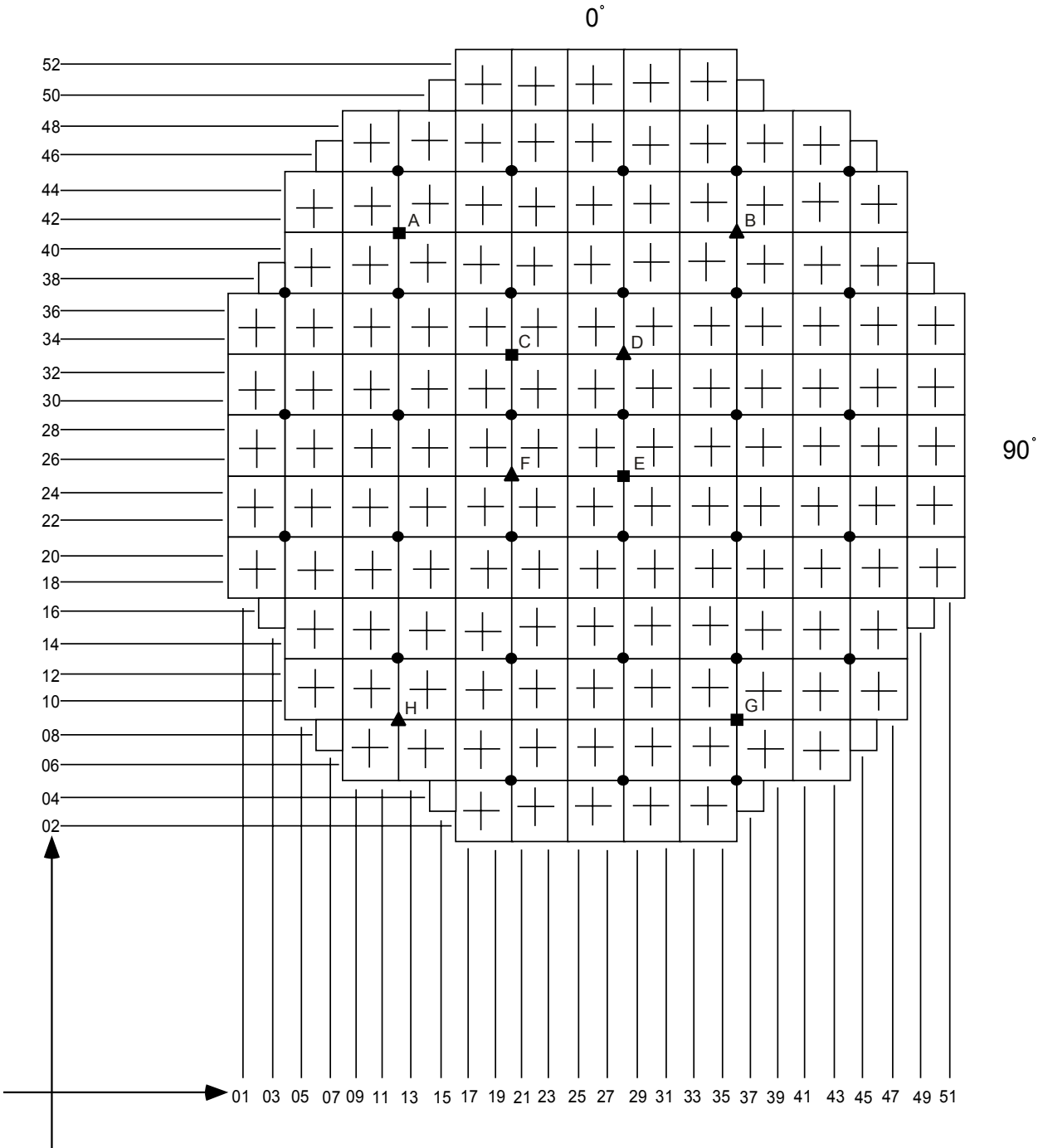
- a miniature fission detector
- electronic signal conditioning equipment
- readout equipment
- trip units
- a mechanical retraction mechanism

TABLE 5.2-1 IRM Interlocks and Trips

ALARM or TRIP(1)	SETPOINT	IRM CHASSIS INDICATION (2)	Panel 603 INDICATION (3)	ANNUNCIATOR (4)	ACTIO(5)	AUTO BYPASS
IRM Upscale Trip (High scram)	≤120 of 125 Scale	UPSCALE Trip (Red Light) (A-H)	UPSC TR or INOP(A-H)	IRM UPSCALE TRIP or INOP (A or E, B or F, C or G, D or H)	Scram	Mode Sw. in RUN with companion APRM NOT Downscale or Bypass Switch in bypass
IRM Upscale Alarm (High)	≤ 108 of 125 Scale	UPSCALE Alarm (Amber Light) (A-H)	UPSC Alarm	IRM UPSCALE	Rod Withdraw Block	Mode Sw. in RUN or Bypass Switch in bypass
IRM Downscale	≤ 5 of 125 Scale	DOWNSCALE (White Light)	DNSC	IRM DOWNSCALE	Rod Withdraw Block	Mode Sw. in RUN, IRM on range 1, or Bypass Switch in bypass
IRM INOP	(6)	INOP (White Light) (A-H)	UPSC TR or INOP (A-H)	IRM UPSCALE TRIP or INOP (A/E, B/F, C/G, D or H)	Rod Withdraw Block ----- Scram	Mode Sw. in RUN with companion APRM NOT Downscale or Bypass Switch in bypass
IRM Detector not fully inserted	Detector not full in				Rod Withdraw block	Mode Sw. in RUN or Bypass Switch in bypass
IRM Bypassed	Bypass Switch (7)	Bypassed (White Light)	Bypass (A-H)		Bypasses all trip functions of the IRM bypassed.	

NOTES FOR TABLE 5.2-1

1. All trips signals automatically reset when the trip condition is cleared. Trip indicators on the IRM chassis must be manually reset.
2. The trip status lights on the IRM drawer front panel operate regardless of mode switch position.
3. Operation of all Panel 603 trip status lights is bypassed with the mode switch in the run position.
4. All IRM annunciators are bypassed with the mode switch in the run position.
5. IRM retraction produces a rod block except when the mode switch is in the run position or the channel is bypassed.
6. This is produced by the following:
 - a. IRM mode switch not in operate
 - b. High voltage low (<80 VDC)
 - c. Module unplugged
7. Only one IRM in each channel (A or B) may be bypassed.



- ⊕ Control Rod
- LPRM String
- IRM Detector (RPS "A")
- ▲ IRM Detector (RPS "B")

Figure 5.2-1 Intermediate Range Monitor Detector Location

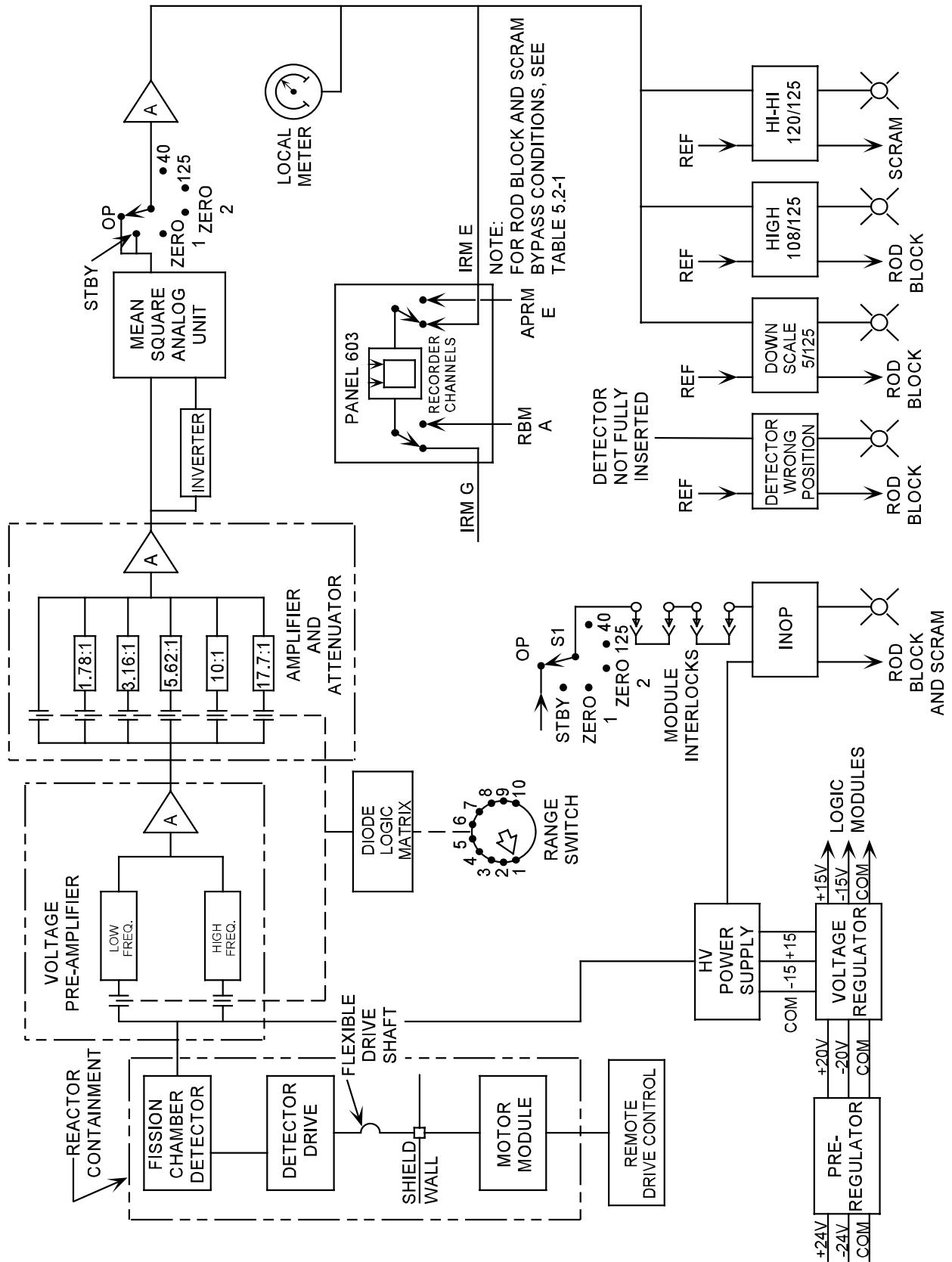


Figure 5.2-2 Intermediate Range Channel Functional Block Diagram

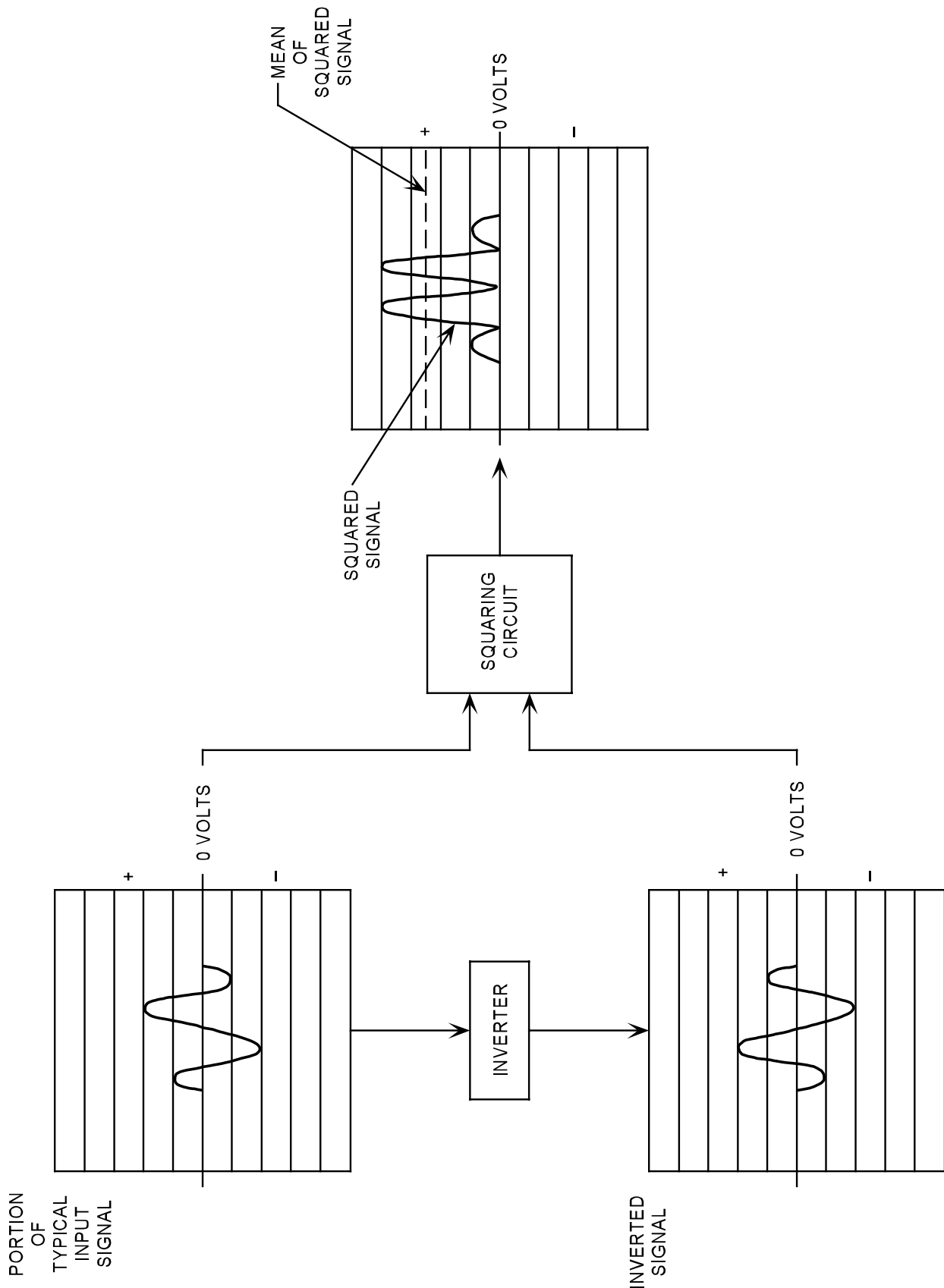


Figure 5.2-3 Mean Square Analog Operation

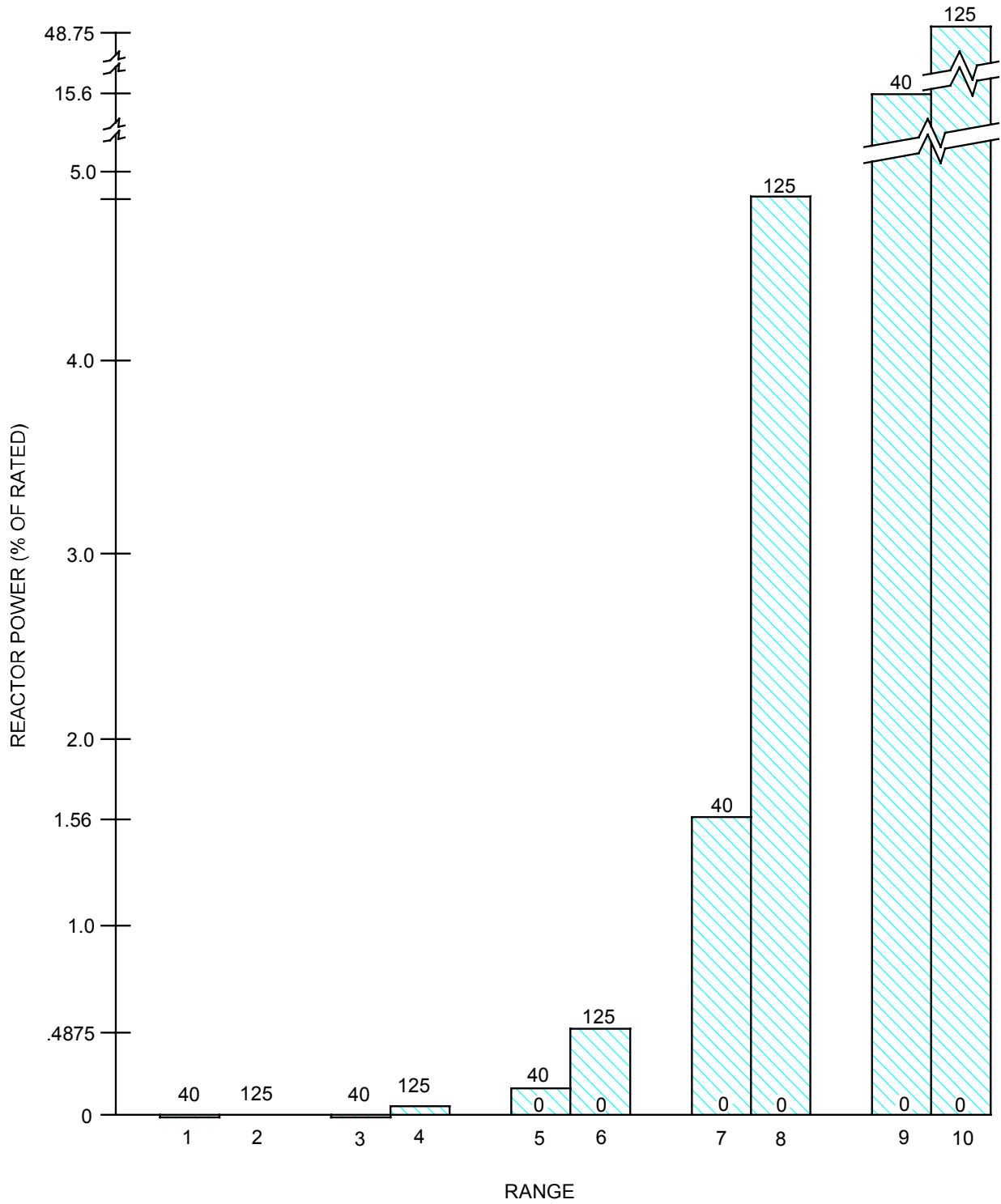


Figure 5.2-4 IRM Range and Scale Relationships

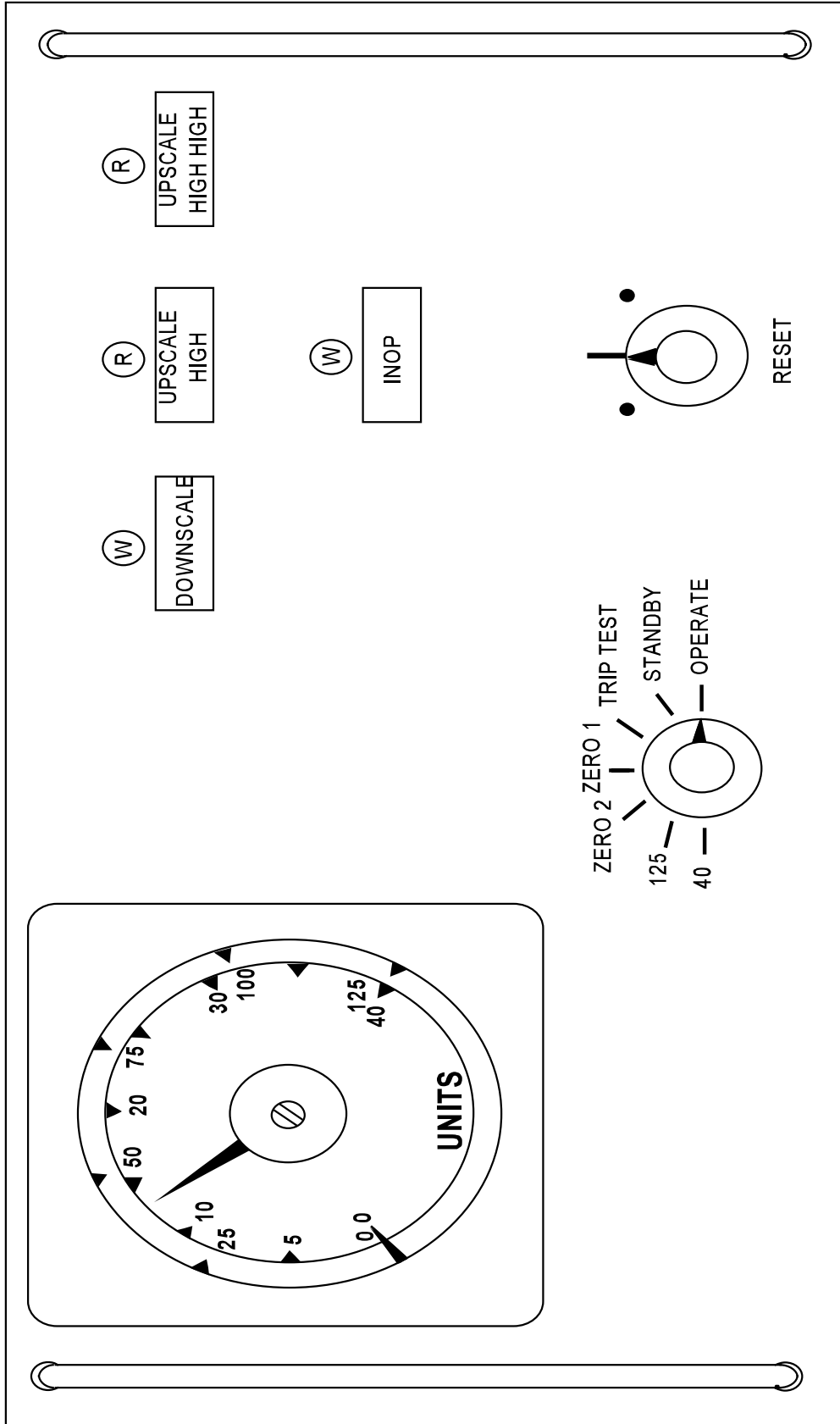


Figure 5.2-5 IRM Drawer Front Panel Layout

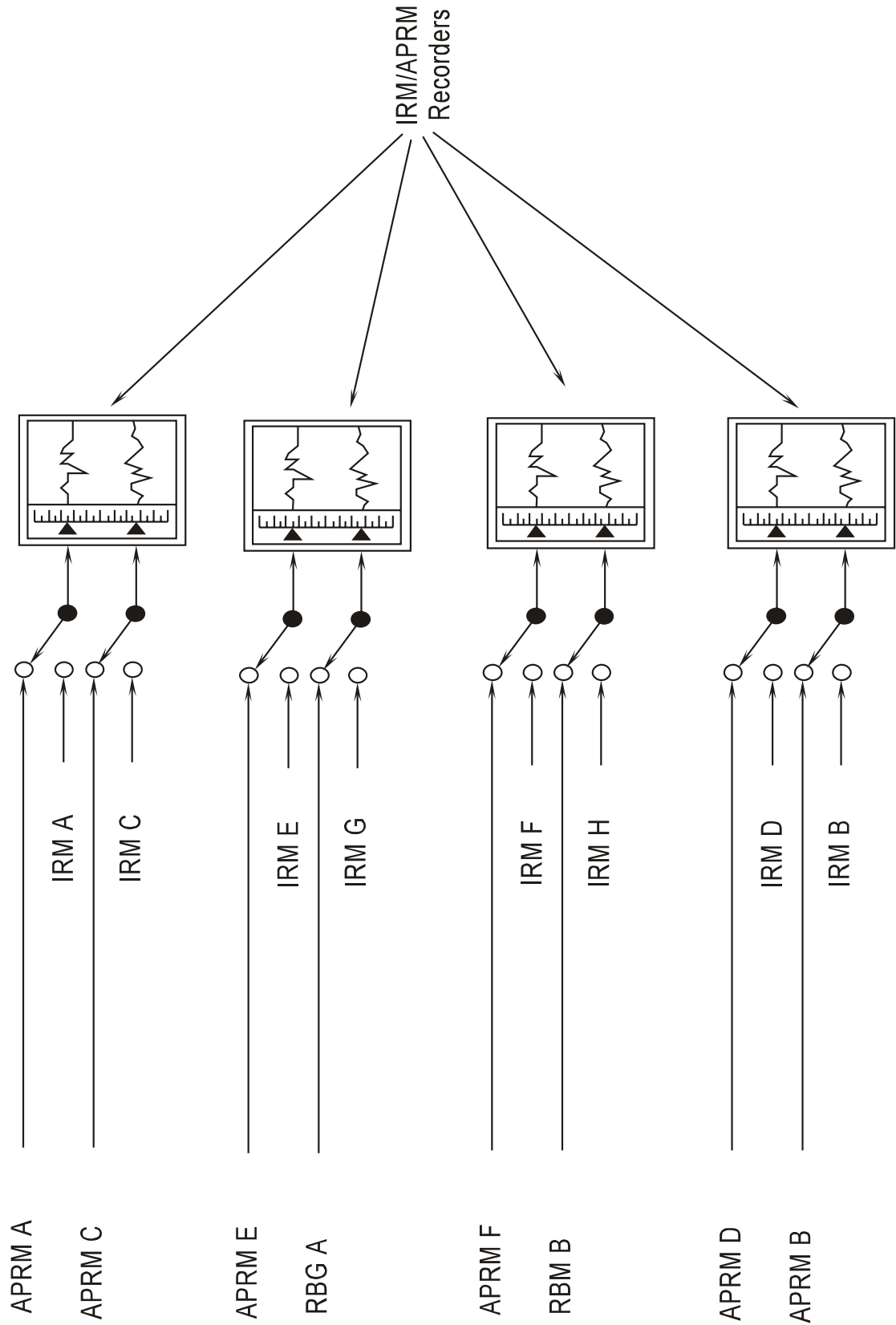


Figure 5.2-6 IRM and APRM Recorder Assignments