TENNESSEE VALLEY AUTHORITY

CHATTANOOGA, TENNESSEE 37401
400 Chestnut Street Tower II

October 20, 1983

Mr. Harold R. Denton, Director
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Denton:

In the Matter of the) Docket No. 50-259
Tennessee Valley Authority)

By letters from D. B. Vassallo to H. G. Parris dated September 20 and 21, 1983, we received requests for additional information regarding the analog instrumentation being installed on Browns Ferry unit 1. Our response to the letter dated September 21, 1983 is provided in enclosure 1. Response to the September 20 letter is provided in enclosure 2.

Startup of Browns Ferry unit 1 is projected for November 28, 1983.

Very truly yours,

TENNESSEE VALLEY AUTHORITY

L. M. Mills

L. M. Mills, Manager
Nuclear Licensing

Subscribed and sworn to before
me this 20th day of October 1983.

Paulette H. White

Notary Public
My Commission Expires 9-5-84

Enclosures
cc: See page 2

A001
1/1

cc (Enclosures):
U.S. Nuclear Regulatory Commission
Region II
ATTN: James P. O'Reilly, Regional Administrator
101 Marietta Street, NW, Suite 2900
Atlanta, Georgia 30303

Mr. R. J. Clark
Browns Ferry Project Manager
U.S. Nuclear Regulatory Commission
7920 Norfolk Avenue
Bethesda, Maryland 20814

ENCLOSURE 1

RESPONSE TO LETTER FROM D. B. VASSALLO TO H. G. PARRIS
DATED SEPTEMBER 21, 1983
REGARDING ANALOG TRIP SYSTEM
BROWNS FERRY NUCLEAR PLANT UNIT 1

QUESTION 1

It is apparent from a review of the modifications to the Technical Specifications that not all channel functional tests are to be performed at 31-day intervals (e.g., Table 4.1.A, Turbine first stage pressure permissive specifies 3 month intervals). Also, Table 4.1.A Note 7 does not discuss adjustments, if necessary, of the alarm, interlock and/or trip setpoints such that the setpoints are within the required range and accuracy. With the proposed Technical Specifications, the NRC staff believes that the reactor protection system instrument setpoints are to be verified only at 18-month intervals during the channel calibration for most channels. Although the staff has not performed a detailed review of the methodology used to establish the trip setpoints for the Browns Ferry facility, the assumptions of the setpoint methodology typically used for the General Electric supplied systems would include a more frequent setpoint verification and adjustment.

Therefore, for each reactor protection system instrument channel where the analog trip system has been added, confirm that the method and frequency for determining the trip unit setpoints and resetting the setpoints is consistent with the assumptions of the setpoint methodology and the drift goals for the instrumentation and associated systems.

RESPONSE

Minimum frequencies for functional tests that appear in table 4.1.A were not changed from the current technical specifications in the subject submittal. Since the analog trip instruments have been evaluated and determined to be more reliable than the mechanical switches for which they are a direct replacement, an equal or larger surveillance frequency is justified.

We expect to verify setpoints as part of the functional test for analog trip instruments because of the simplicity of doing so. Setpoints which are found to be outside of the range specified by the plant setpoint methodology will be corrected.

QUESTION 2

The terminology for channel calibration as used in Note 9 of Table 4.1.B does not provide a clear definition as to which components are included. Therefore, for each reactor protection system instrument channel where the analog trip system has been added, confirm that the channel calibration performed at the 18-month interval encompasses the entire channel including the sensors, alarm interlocks, and/or trip functions.

RESPONSE

The purpose of note 9 of table 4.1.B is to augment the definition of instrument calibration (TS 1.V.1) to clarify its applicability to analog trip instruments and associated components. Note 9 states that calibration involves adjustment of components such that the instrument reading corresponds to known values of the process variable, and the trip circuitry be adjusted such that the trip output relay changes state at the proper analog value. In accordance with note 9, the channel calibration performed at 18-month intervals encompasses all of the components including sensors, alarm interlocks, and/or trip functions out to and including the trip output relay. The remainder of the trip components are logic devices only and are tested during instrument functional tests on a more frequent interval as required by table 4.1.A.

QUESTION 3

It is apparent from a review of the modifications to the Technical Specifications (Table 4.2.A) that not all instrument channel checks are to be performed each shift (e.g., high drywell pressure, reactor low water level, reactor high pressure). This is not consistent with the provisions of the Standard Technical Specifications (STS) for this type of instrumentation. The STS include instrument channel checks each shift. Therefore, for each reactor protection system channel where the analog trip system has been added, confirm that the instrument channel checks are being performed each shift and propose revised Technical Specifications to document these checks; or justify less frequent checks.

RESPONSE

The subject technical specification amendments do not change the frequency of instrument checks as defined in table 4.2.A. Once/day checks was previously justified and approved by NRC. Compliance with the Standard Technical Specifications is not a requirement for Browns Ferry.

ENCLOSURE 2

RESPONSE TO LETTER FROM D. B. VASSALLO TO H. G. PARRIS
DATED SEPTEMBER 20, 1983
REGARDING ANALOG TRIP SYSTEM
BROWNS FERRY NUCLEAR PLANT UNIT 1

Topic 1 - Identification of the systems and monitored parameters involved.

Attachment 1 contains a description of the instrumentation to be installed as part of the analog trip system installation at Browns Ferry. Attachment 1 also contains environmental operating conditions under which the instrumentation must operate and the environmental conditions for which they are qualified including a separate seismic response evaluation.

Topic 2 - Reference to NRC-approved Topical Reports (i.e., NEDO-21617).

The instrumentation which is installed and will be installed as part of the analog trip system at Browns Ferry is the same or better than the instrumentation which is described in General Electric Company NEDO-21617. Information given in attachment 1 demonstrates applicability of this topical report to the system proposed for Browns Ferry.

Topic 3 - A detailed comparison of the design to the requirements of IEEE Standard 279, GDC 2, GDC 4, GDC 13, GDC 19, GDC 20, GDC 21, GDC 22, GDC 23, GDC 24, GDC 25, and GDC 29 specifically identifying deviations from these requirements.

A comparison of the analog trip system which is being installed at Browns Ferry, the regulatory guides, IEEE standard, and the GDC is contained in attachment 2.

Topic 4 - A detailed discussion of conformance to the following regulatory guides, 1.22, 1.47, 1.53, 1.62, 1.75, 1.105, and 1.118.

A comparison of the analog trip system which is being installed at Browns Ferry, the regulatory guides, IEEE standard, and the GDC is contained in attachment 2.

Topic 5 - Identification of the types of isolation devices used as boundaries to isolate nonsafety-related circuits from safety-related circuits or to isolate safety-related circuits.

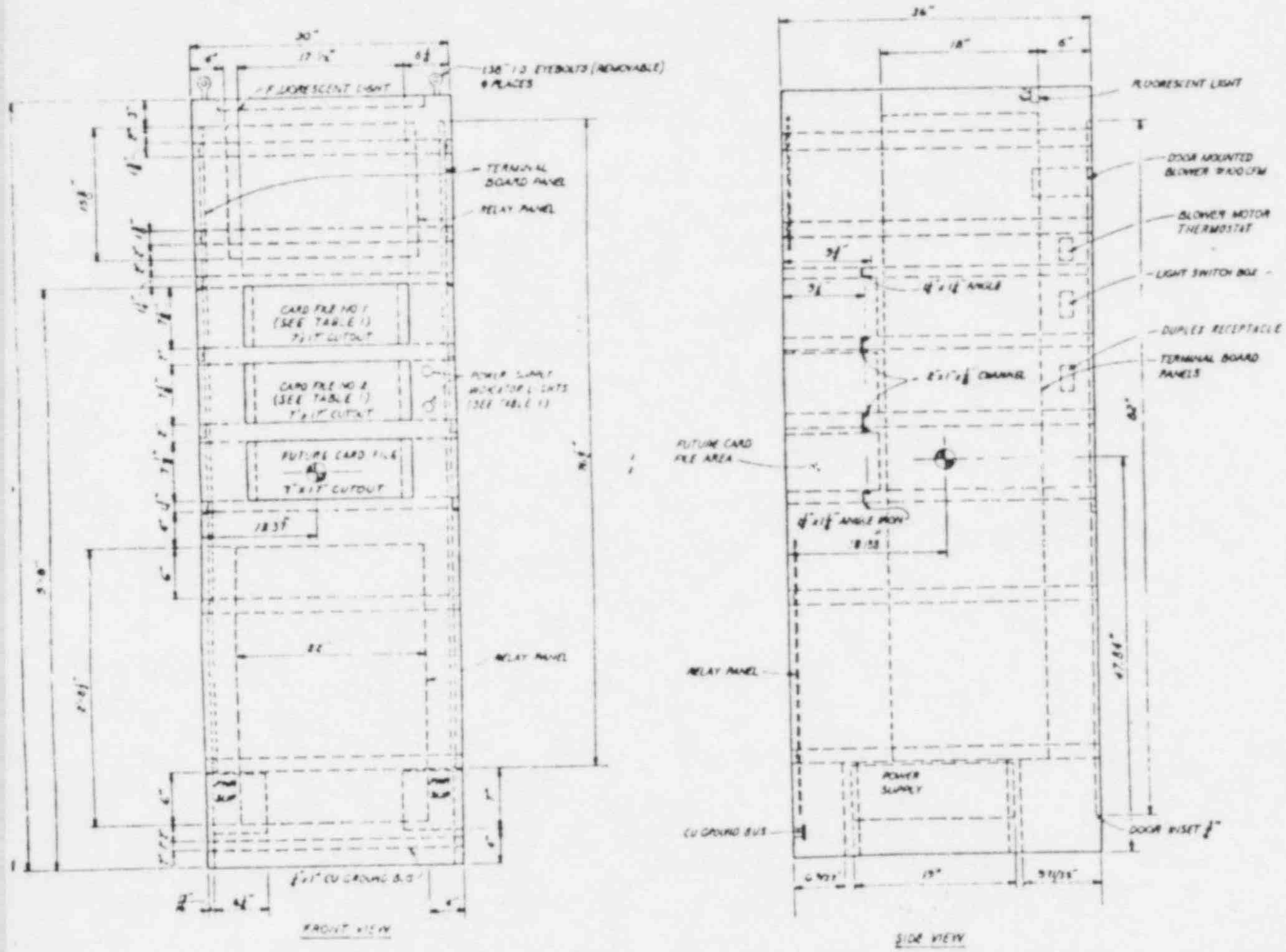
There are no direct connections between safety-related and nonsafety-related circuits in the analog trip system installed on Browns Ferry unit 1; therefore, isolation devices are not necessary. Isolation between 1E power and non-1E power is provided by mechanical interface relays mounted on the analog trip channel cabinets. This interface occurs only between the plant annunciator system and the analog trip circuits for gross failure and card-out alarms. Specifically, the annunciator interface relays have class 1E power at the relay coils supplied by the analog trip unit power supplies, but non-class 1E power is supplied to the relay contacts from the annunciator system power supplies.

Applicable drawings showing RPS logic and wiring diagrams for the RPS analog trip units have been previously provided under separate cover.

Variable Name	Vendor Model No. Being Deleted	System Involved	Equipment Being Installed: Transmitter Model No.	Equipment Being Installed: Trip Unit Model No.	TVA Instrument Loop No. and Division	
Reactor low water level	Barton Model No. 278	Reactor Protection	Rosemount 1153	Rosemount 710 DU	L-3-203A (IA) L-3-203B (IB)	L-3-203C (IIA) L-3-203D (IIB)
Reactor high pressure	Barksdale Model No. B2T-A12SS	Reactor Protection	Rosemount 1153	Rosemount 710 DU	P-3-22AA (IA) P-3-22BB (IB)	P-3-22C (IIA) P-3-22D (IIB)
Reactor low low water level	Yarway Model No. 4418C	Primary Containment isolation and recirc pump trip	Rosemount 1153	Rosemount 710 DU	L-3-56A (IA) L-3-56B (IA)	L-3-56C (IIA) L-3-56D (IIB)
Main steam line low pressure	Barksdale Model No. B2T-A12SS	Primary Containment isolation	Rosemount 1153	Rosemount 710 DU	P-1-72 (IA) P-1-76 (IB)	P-1-82 (IIA) P-1-86 (IIB)
Main steam line high flow	Barton Model No. 278	Primary Containment isolation	Rosemount 1153	Rosemount 710 DU	dP-1-13A, -25A, -36A, -50A (IA) dP-1-13B, -25B, -36B, -50B (IB) dP-1-13C, -25C, -36C, -50C (IIA) dP-1-13D, -25D, -36D, -50D (IIB)	
Primary Containment high pressure	Static-o-ring Model No. 12N-AA4-X2PP	Reactor protection and primary containment isolation	Rosemount 1153	Rosemount 710 DU	P-64-56A (IA) P-64-56B (IB)	P-64-56C (IIA) P-64-56D (IIB)
Turbine first stage pres. permissive	Barksdale Model No. B2T-A1255	Reactor protection and recirc. pump trip	Rosemount 1153	Rosemount 710 DU	P-1-91B (IA) P-1-91A (IB)	P-1-81B (IIA) P-1-81A (IIB)
Reactor high pressure	Static-o-ring Model No. 9N-AA4-X911	Recirc. pump trip	Rosemount 1153	Rosemount 710 DU	P-3-204A (IA) P-3-204B (IB)	P-3-204C (IIA) P-3-204D (IIB)

ATTACHMENT 1

TRIP UNIT CABINET



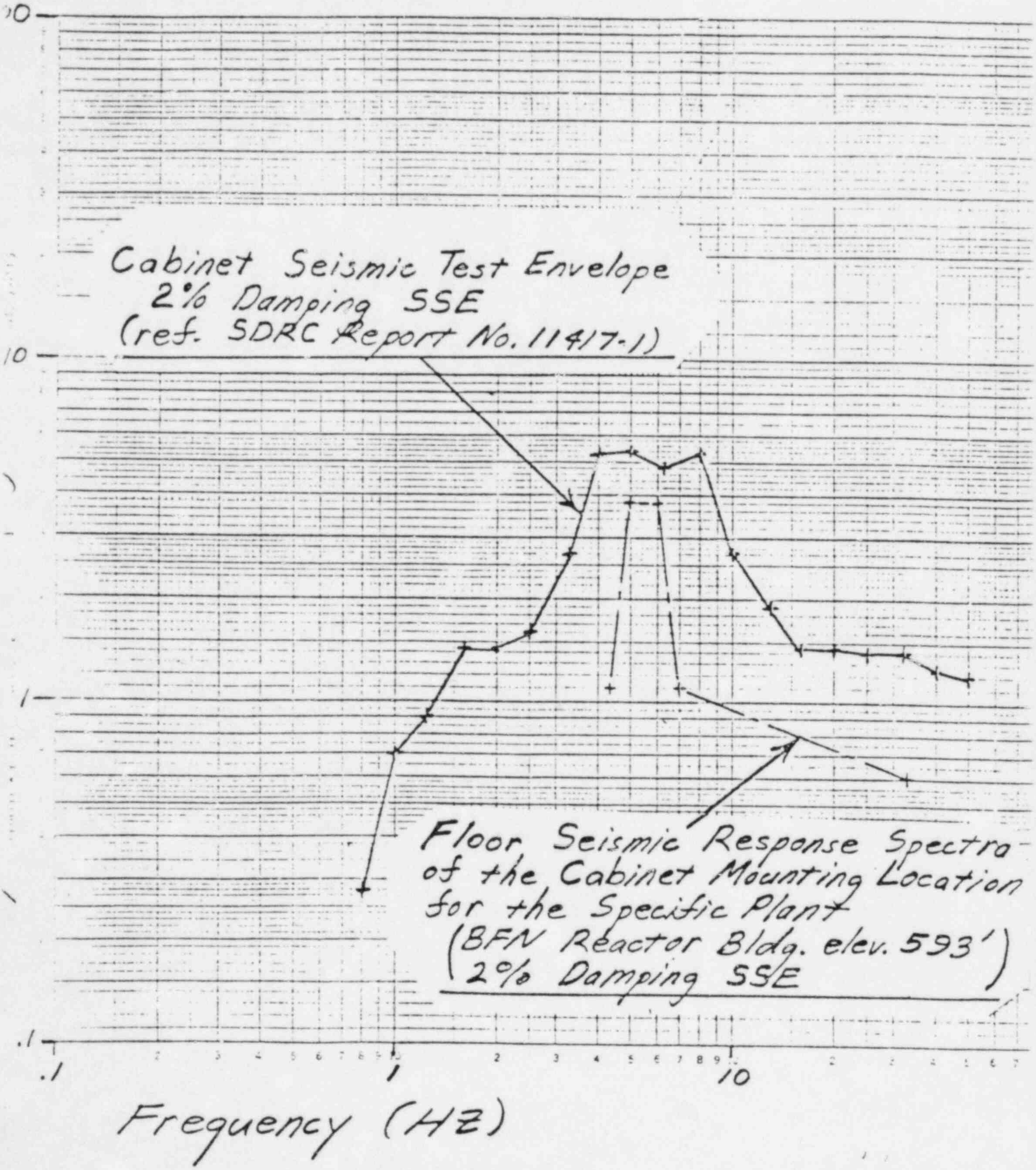
		RPS A1 PANEL 9-83	RPS A2 PANEL 9-85	RPS B1 PANEL 9-84	RPS B2 PANEL 9-86
[illegible]		PS-99-A1 & A1A	PS-99-A2 & A2A	PS-99-B1 & B1A	PS-99-B2 & B2A
PWR SUPPLY		IL-99-A1	IL-99-A2	IL-99-B1	IL-99-B2
IND LIGHTS		IL-99-A1A	IL-99-A2A	IL-99-B1A	IL-99-B2A
ANNUNCIATOR		XA-99-1 (NOTE 12)			
CARD FILE 1	1	PDIS-1-13A	PDIS-1-13C	PDIS-1-13B	PDIS-1-13D
	2				
	3	PDIS-1-25A	PDIS-1-25C	PDIS-1-25B	PDIS-1-25D
	4				
	5	PDIS-1-36A	PDIS-1-36C	PDIS-1-36B	PDIS-1-36D
	6				
	7	PDIS-1-50A	PDIS-1-50C	PDIS-1-50B	PDIS-1-50D
	8				
	9	PIS-1-72	PIS-1-83	PIS-1-76	PIS-1-84
	10				
	11	PIS-1-91B	PIS-1-81B	PIS-1-91A	PIS-1-81A
	12				
	13	XIS-99-1	XIS-99-2	XIS-99-1B	XIS-99-2B
	14				
CARD FILE 2	1	PIS-3-22AA	PIS-3-22C	PIS-3-22BB	PIS-3-22D
	2	LIS-3-56A	LIS-3-56C	LIS-3-56B	LIS-3-56D
	3	LIS-3-208A	LIS-3-208C	LIS-3-208B	LIS-3-208D
	4	LS-3-56A	LS-3-56C	LS-3-56B	LS-3-56D
	5	PIS-3-204A	PIS-3-204C	PIS-3-204B	PIS-3-204D
	6				
	7	PIS-64-56A	PIS-64-56C	PIS-64-56B	PIS-64-56D
	8	LIS-85-45A	LIS-85-45B	LIS-86-45G	LIS-86-45H
	9	LS-85-45A	LS-86-45D	LS-85-45B	LS-86-45H
	10				
	11				
	12				
	13	XIS-99-1A	XIS-99-2A	XIS-99-1BB	XIS-99-[illegible]
	14				

ENVIRONMENTAL QUALIFICATION

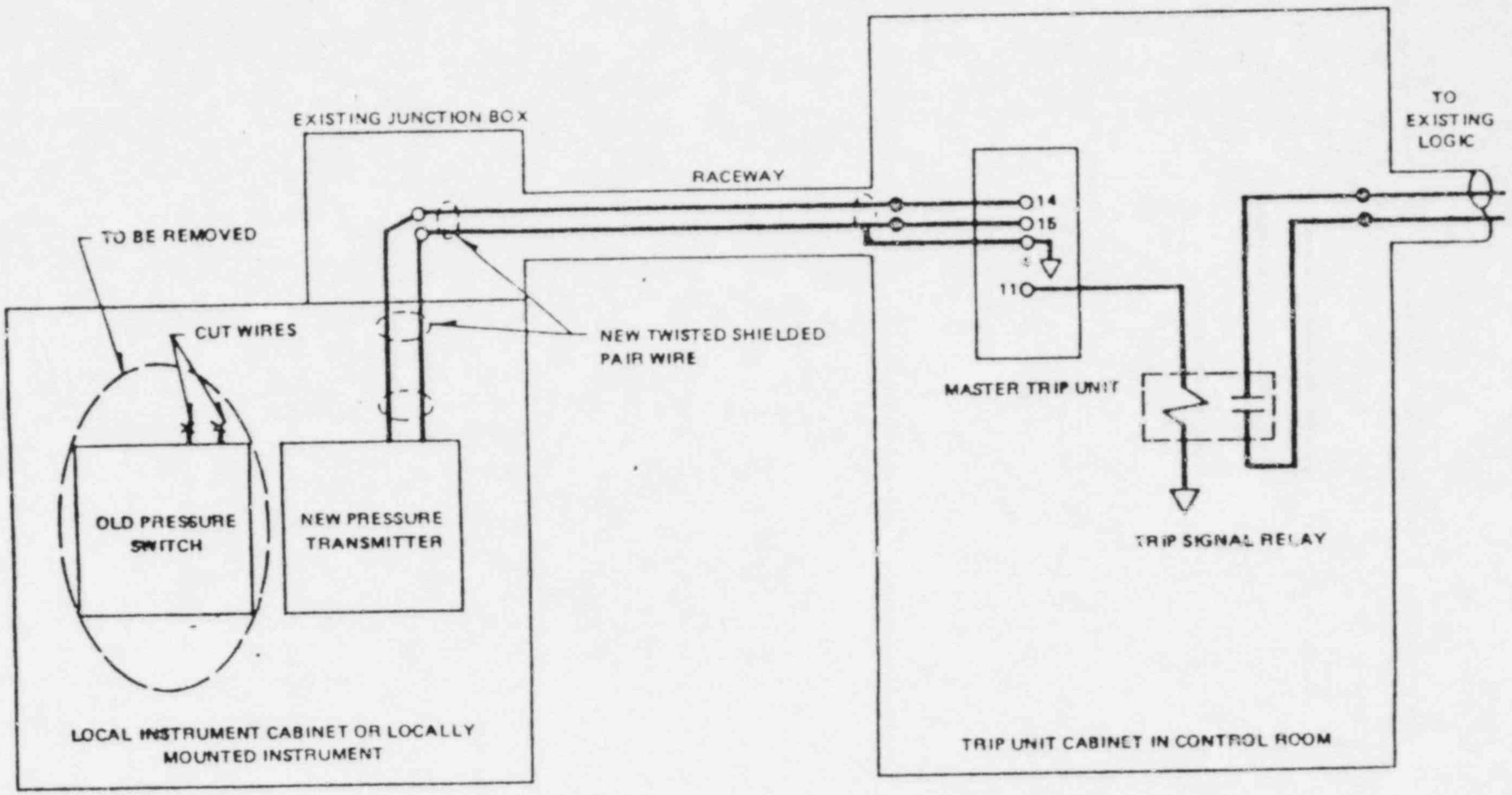
Transmitter No.	Normal Temp.(1)	Normal Humidity(1)	Accident Temp.(1)	Accident Humidity(1)	Qualified Temp.(1) (3)	Qualified Humidity(1)
1-LT-3-203 A, B, C, D	90°F	98%	180°F	100%	303°F	100%
1-PT-3-22 A, B, C, D	90°F	98%	180°F	100%	303°F	100%
1-LT-3-56 A, B, C, D	90°F	98%	180°F	100%	350°F	100%
1-PDT-1-13 A, B, C, D	95°F	98%	117°F	100%	350°F	100%
1-PDT-1-25 A, B, C, D	95°F	98%	117°F	100%	350°F	100%
1-PDT-1-36 A, B, C, D	95°F	98%	117°F	100%	350°F	100%
1-PDT-1-50 A, B, C, D	95°F	98%	117°F	100%	350°F	100%
1-PT-64-56 A, B, C, D	90°F	98%	110°F	100%	303°F	100%
1-PT-3-204 A, B, C, D	90°F	98%	100°F	100%	303°F	100%
1-PT-1-72, 76, 82, 86	90°F	98%	N/A(2)	N/A(2)	303°F	100%
1-PT-1-81 A, B, 91A, B	90°F	98%	N/A(2)	N/A(2)	303°F	100%

(1) Maximum
(2) Equipment located where it will not be subjected to harsh environmental conditions.
(3) The two values of qualified temperature are for series 1153 models B and D.

ENVIRONMENTAL INTERFACE
SEISMIC RESPONSE



PLANT INTERCONNECTION



ATTACHMENT 2

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TABLE 1

Criteria No.	Description
GDC No. 2	Design basis for protection against natural phenomenon
GDC No. 4	Environmental and missile design basis
GDC No. 13	Instrumentation and control
GDC No. 19	Control room
GDC No. 20	Protection system functions
GDC No. 21	Protection system reliability and testability
GDC No. 22	Protection system independence
GDC No. 23	Protection system failure modes
GDC No. 24	Separation of protection and control systems
GDC No. 25	Protection system requirements for reactivity control malfunctions
GDC No. 29	Protection against anticipated operational occurrences
RG 1.22	Periodic testing of protection system actuation functions
RG 1.47	Bypassed and inoperable status indication for nuclear power plant safety systems
RG 1.53	Application of single failure criterion to nuclear power plant safety systems
RG 1.62	Manual initiation of protective actions
RG 1.75	Physical independence of electric systems
RG 1.105	Instrument setpoints
RG 1.118	Periodic testing of electric power and protection systems
IEEE 279-1971	Criteria for protection system

REFERENCES

1. Operations manual trip/calibration system model 710DU (4471-1 Rev. A).

2. Browns Ferry Nuclear Plant FSAR Section 7.2, "Reactor Protection System."

1.0 System Description

The primary sensors for the reactor protection system (RPS) are being replaced by Rosemunt transmitters and trip units. Basic RPS operation is described in the Browns Ferry Nuclear Plant Final Safety Analysis Report (FSAR) in section 7.2. The following paragraphs only address the changes to the RPS and the impact these changes have on the conformance of the RPS to its design basis and the standards noted in table 1.

2.0 General Summary Discussion

The transmitter-trip units are direct replacements of the existing mechanical trip switches that provide RPS trip inputs. The selection of which plant variables should be used to provide RPS trip inputs is justified in the BFN FSAR in section 7.2.3.6. Since no plant variables have been deleted or added due to the installation of the transmitter-type units, the RPS meets the pertinent sections of general design criteria (GDC) 13, 20, 25, and 29.

The trip units are located in four cabinets in the auxiliary instrument room (AIR). These trip units are divided into four channels A1 and A2 and B1 and B2. Any combination of sensor inputs that meets the expression (A1+A2)x(B1+B2) will initiate RPS protective action. All of the logical combinations are accomplished at the system level and are not modified by the installation of the transmitter trip units. Each channel of trip units is housed in its own panel in the AIR (panels 9-83, 9-84, 9-85, and 9-86). Also, each channel provides input to only one channel of RPS logic which, as stated above, performs the logical combination which controls the RPS protective actions. Each channel also provides output to non-IE systems, namely the annunciator system, and the reactor recirculation pump trip circuitry. Because each channel is located in its own cabinet, and the external wiring is separated (see section 3), the separations of the RPS channels are maintained and the requirements of GDC 21, 22, 24, and Regulatory Guide 1.75 (as it applies to Browns Ferry) are met.

The transmitters and trip units have been qualified for the environments in which they are required to operate. The transmitters are physically located on the local panels that the mechanical switches were removed from and on additional panels being installed at these locations; therefore, the missile design for the RPS inputs has not changed; therefore, applicable portions of GDC 2, 4, 22, and 23 are met.

Unlike the mechanical switches that the transmitter trip units are replacing, the new equipment requires electric power to operate. The dependence of the trip units and transmitters on electric power has been eliminated by making them fail safe (tripped) on loss of power as is the case with existing RPS logic. Also, note from the system drawing that the transmitter trip units are powered from the redundant power supplies.

There are no new single failures relating to power loss for the RPS. The consequences of the loss of the MG-set power source is the same as it was before the transmitter trip unit installation, and the loss of a single trip unit cabinet power supply does not disable the trip units because it is backed up with a redundant power supply. Since there are no new power supply related failure modes, the transmitter trip units are directly replacing the existing mechanical trip switches, and since there are no system level changes, it can be demonstrated that the RPS automatic and manual systems still meet the requirements of Regulatory Guide 1.62, IEEE standard 279, section 4.17 and GDC 23.

The transmitter trip units are tested from the auxiliary instrument room using built in circuitry unlike the mechanical switches. The method in which they will be tested does not require valving out the sensors, attaching actuation equipment, and actuating the sensor which is a time consuming process. This reduces the time that the RPS logic is in a degraded condition (i.e., 1 of 2)x2 logic reduced to (1 of 2) and 1. The method of testing the transmitters and trip units is discussed in the operations manual and summarized below:

> The operation of the transmitters is verified by comparing redundant indications on the master trip units.
>
> The operation of the trip unit and auxiliary relay at the proper setpoint is verified by using the built-in calibration unit. Note the calibration unit can only test one trip unit at a time and, when any trip unit is being tested, the condition alarms in the main control room on panel 9-5.
>
> Following verification of proper trip unit operation, the calibration unit is returned to its normal position, and the indications on the master trip units are checked to verify that the transmitters are properly reconnected.

As noted in the above testing description, the trip units alarm in the MCR on panel 9-5 when they are bypassed. They also alarm on the following conditions:

> Trip unit in test,
>
> Input signal to trip unit out-of-range (gross failure),
>
> Trip unit out-of-file (card out),
>
> One of two power supplies failed.

In summary, the implementation of the transmitter trip units has enhanced the conformance of the RPS to the applicable NRC requirements. The transmitter trip units have not induced any additional failure modes and have made the testing and surveillance of the RPS sensors quicker and more informative (channel is actively returned to service).

In conclusion, the addition of the transmitter trip units to the RPS meets the requirements of the applicable GDC and regulatory guides.

3.0 Detailed Point By Point Discussions

A. Conformance to Regulatory Guide 1.62 and section 4.17 of IEEE 279, "Manual Initiation."

The manual initiation of the RPS protective functions is accomplished at the system level and is not affected by the installation of the transmitter trip unit system (refer to drawing No. 730E915 for RPS manual initiation circuitry); therefore, the requirements are met.

B. Conformance to Regulatory Guide 1.53 and section 4.2 of IEEE 279, "Single Failure Criteria."

The transmitter trip units are directly replacing the mechanical switches in the RPS. A single failure of a transmitter or trip unit is acceptable because the RPS is a (1 of 2)x2 logic system, and it would take at least two sensor failures to prevent proper RPS operation. Although the transmitter trip units require power to operate, they are installed such that they trip on loss of power. Due to the above two points, it is concluded that there are no new single failure modes introduced that could prevent the RPS from performing its safety function; therefore, the requirements are met.

C. Conformance to Regulatory Guides 1.22 and 1.47, GDC 20 and 21, and sections 4.9, 4.10, 4.11, 4.12, 4.13, 4.14, and 4.18 of IEEE 279. Periodic testing of protection systems and indication of bypassed condition.

The operability of the trip unit and auxiliary relays is verified by periodic functional testing using special test equipment supplied as part of the analog trip system. Operability of the transmitters is verified by periodic comparison above the indicators on the master trip units which monitors the same parameter. Gross transmitter failure is detected by special monitoring circuits in the analog trip units and is annunciated in the main control room. Main control room annunciation is provided to indicate when a trip unit is out-of-service or is being functionally checked.

The transmitters and analog trip units meet the appropriate requirements of the referenced regulatory guides, GDC, and IEEE-Standard sections.

D. Conformance to Regulatory Guide 1.75 and Sections 4.6 and 4.22 of IEEE 279, "Physical Independence of Electric Systems and Identification of Divisionalized Equipment."

Each panel of transmitter trip units provides trip signals to only one channel of the RPS. It also provides signals to the non-IE annunciator and reactor recirculation pump trip system (refer to drawings 73DE320 RE, RF, and RH and 45N6206 and 47W761 series). All utility intrapanel wiring is done in flexible conduit.

E. Conformance to GDC 29, 23, 13, 4, and 2 and IEEE 279 sections 4.3, 4.4, and 4.5. Qualification of transmitter trip units.

The transmitters and trip units have been qualified to the worst environment under which they must function; therefore, the equipment is considered to meet the referenced requirements.

F. Conformance to Regulatory Guide 1.105, "Instrument Setpoints."

Intrinsically, after random failures, electronic modules will not drift at the rate of mechanical devices (such as blind pressure switches), and significant abnormalities are indicated by the gross failure alarm feature of the trip units. The trip units are designed to receive a 4 to 20 mA transmitter signal and provide an output at a specific input signal. The modules are selected such that this requirement is met. The recommendation of Regulatory Guide 1.105 is not applicable to these devices.

G. Conformance to Regulatory Guide 1.118, "Periodic Testing of Electric Power and Protection Systems."

Regulatory Guide 1.118 is not a licensing requirement for Browns Ferry; however, since installation of the analog trip system only involves improvements of simple elements of the total system, no changes have been made that are inconsistent with this Regulatory Guide

H. Conformance to IEEE 279-1971 (sections 4.1, 4.7, 4.8, 4.15, 4.16, 4.19, 4.20, and 4.21). All other sections have been addressed in the preceding sections.

1. <u>Section 4.1 - "Automatic Actions"</u>

The function of the transmitter trip units and the RPS is the automatic initiation of protective actions; therefore, this section's requirements are met.

2. Section 4.7 - "Control and Protection System Interaction"

   The RPS is used only for protective functions, and the transmitter trip units are only used for the RPS; therefore, this section does not apply to the transmitter trip units.

3. Section 4.8 - "Derivation of System Inputs"

   The transmitter trip units directly measure the plant variables required by the RPS as discussed in section 7.2.3.6 of the FSAR; therefore, this section's requirements are met.

4. Section 4.15 - "Multiple Setpoints"

   The RPS system does not utilize multiple setpoints for any of its plant variables under different plant operating conditions; therefore, this section does not apply.

5. Section 4.16 - "Completion of Protective Action"

   The RPS system once actuated by sensor inputs must be manually reset; therefore, this section's requirement are met at the system level.

6. Section 4.19 - "Identification of Protective Actions"

   This is accomplished at the system level and thus was not modified by the installation of analog trip devices

7. Section 4.20 - "Information Readout"

   The trip units provide process indications in the auxiliary instrument room only and these are only used for verification of transmitter operability during testing; therefore, the operator is not provided with anomalous indications that could be misinterpreted. The only indication in the main control room is an annunciator that alerts the operator to trip system problems. These problems can be diagnosed by examining the power failure and gross failure LEDs at the trip units in the AIR. RPS system level status information is already implemented in the RPS system; therefore, the transmitter trip units meet the requirements of this section.

8. Section 4.21 - "Repair"

   The trip units alert the operator to transmitter failures, and the modular design of the transmitter trip system allows for the quick swapping of backup modules into the system.

INSTRUCTION MANUAL 4471-1
Revision A

ATTACHMENT 3

Instruction Manual

Operations Manual
Trip/Calibration System
Model 710DU

Rosemount

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LIST OF TABLES

LIST OF ILLUSTRATIONS

SECTION I
DESCRIPTION

INTRODUCTION

This manual contains complete operating instructions for the Model 710DU Trip/Calibration System manufactured by Rosemount Inc., Minneapolis, Minnesota. Maintenance and repair procedures for the 710DU, including troubleshooting, disassembly, and an illustrated parts breakdown, are contained in Service Manual 4471-2. Bench Test Facility Manual 4471-3 includes complete 710DU bench testing information.

APPLICATION

The 710DU Trip/Calibration System is a multichannel signal conditioning system with a built-in calibration capability. It provides accurate, easily-calibrated trip output signals for processes (pressure, temperature, level, etc.) which are monitored by 4 to 20 mA transmitters or 3-wire platinum RTD's. The trip output signals drive external relays or loads of up to one amp at 24 V. An auxiliary analog output can be used to drive external recording and monitoring equipment, while a second analog output can drive other channels in the 710DU System to provide additional trip points for a single input sensor.

The 710DU Trip/Calibration System is designed specifically for use in nuclear power generating stations. It is qualified to IEEE STD 323-1974 and IEEE STD 344-1975 per Rosemount Report D8200037. Other applications include fossil-fueled power generating stations, petroleum refineries, chemical plants, or industries which utilize either 4 to 20 mA transmitters or 3-wire platinum RTD's and require trip outputs.

SYSTEM UNITS/ASSEMBLIES

The 710DU Trip/Calibration System consists of:

1. Card File
2. Master Trip Units using 4-20 mA Input
3. Master Trip Units using RTD Input
4. Slave Trip Units
5. Calibration Units
6. Readout Assembly
7. Accessory Hardware (includes card extenders and blank panels; see "Accessory Hardware" section of this manual).

When ordering a Trip/Calibration System, the customer can select whichever units or assemblies are required for his particular application. A typical 710DU System is shown in Figure 1.

Brief, functional descriptions of each unit/assembly in the Trip/Calibration System follow. Refer to the "Theory of Operation" section for more detailed information.

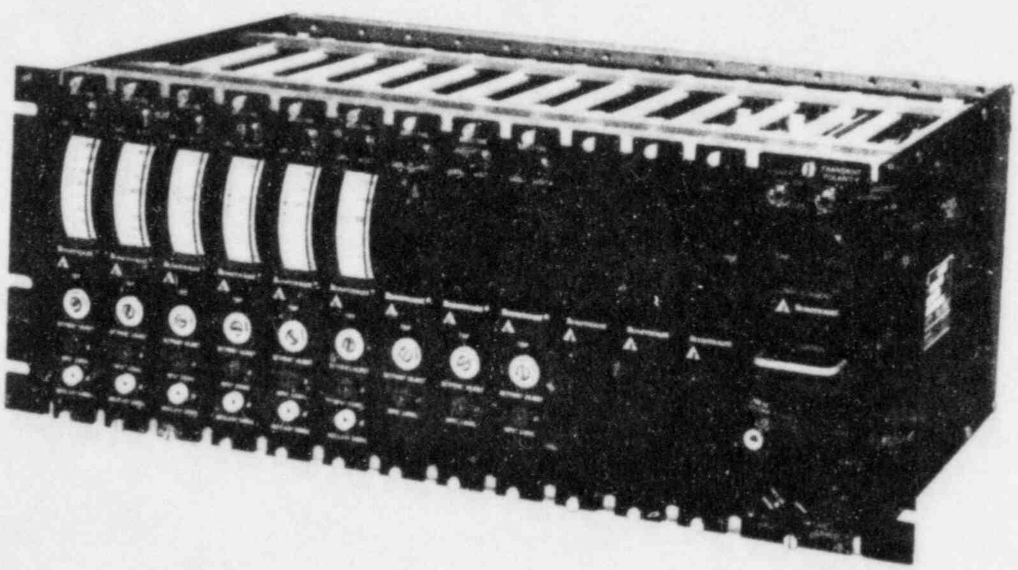


Figure 1. Typical 710DU Trip/Calibration System.

Card File

All units in the 710DU System except the Readout Assembly plug into the electrical connections at the rear of the Card File. Any combination of Master and Slave Trip Units and blank panels can be inserted in the first 12 file locations (left to right as viewed from front of Card File); the Calibration Unit is assigned to location 13 (far right). The Readout Assembly plugs into the Calibration Unit.

The Card File is wired with all interconnecting wires between the Calibration Unit and the Master and Slave Trip Units installed. The Card File mounts in a standard 19-inch relay rack. See the "Wiring and Installation" section for mounting instructions and for a photo of a wired Card File.

Master Trip Units

One Master Trip Unit is required for each 4 to 20 mA transmitter or 3-wire RTD. The Master Trip Unit produces a trip output signal when the input signal passes through a preset trip point, and a gross failure signal when the input signal is outside preset high or low limits.

In addition to trip and gross failure outputs, the Master Trip Unit also produces two buffered analog output voltages proportional to the input signal.

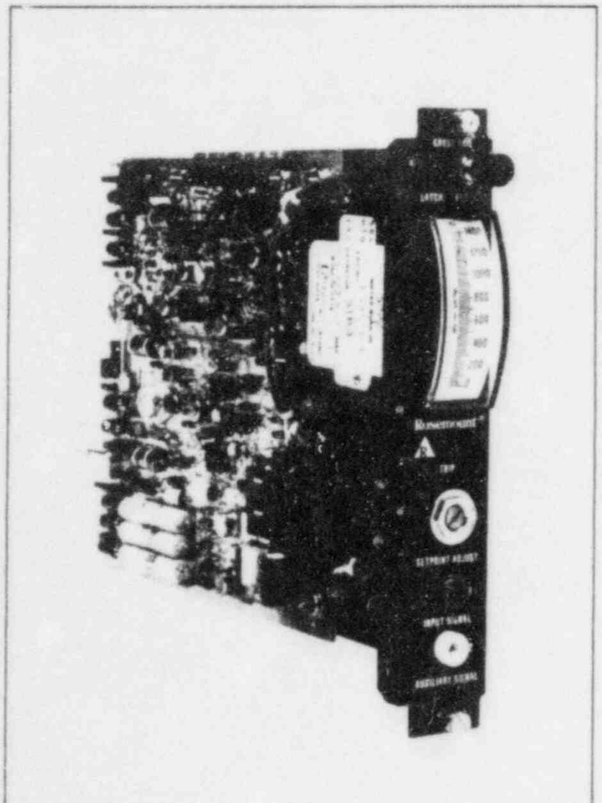


Figure 2. 710DU Master Trip Unit

One analog output is used to drive up to seven Slave Trip Units, thereby establishing as many as eight trip points (one for Master, seven for Slaves) for a single input signal. The second analog voltage, designated the auxiliary analog output, is used to drive external recording or monitoring equipment.

Master Trip Units have a trip point adjustment potentiometer on the front panel, as well as an analog meter displaying the input signal, two light-emitting diodes (LED's) indicating trip and gross failure conditions, a gross failure reset button, and test jacks to monitor the input signal and the auxiliary analog output signal.

The circuit board of a Master Trip Unit includes adjustments for high and low gross failure levels, trip reset differential, trip output logic, and trip status LED logic. In addition, a 4-20mA Input Trip Unit has an adjustment for the frequency response of the auxiliary analog output signal.

The circuit board of a Master Trip Unit with RTD Input also includes potentiometers for adjusting the zero, span, and linearity of the buffered signal.

Refer to Section III of this manual for descriptions of the various adjustments and displays included on Master Trip Units.

A Master Trip Unit is shown in Figure 2.

Slave Trip Units

Each Slave Trip Unit in the 710DU System is driven by a Master Trip Unit, and adds one additional trip point and gross failure circuit to each sensor channel. The Slave Trip Unit receives a buffered 0 to 10 Vac (0-100%) signal (calibrated from 1 to 5 Vdc) proportional to the input signal from a Master Trip Unit. The Slave Trip Unit produces a trip output signal when the input signal passes through a preset trip point, and a gross failure signal when the input signal is outside preset high or low limits.

The front panel of each Slave Trip Unit includes a trip point adjustment potentiometer, LED's indicating trip and gross failure outputs, a gross failure reset button, and a test jack to measure the input signal from the Master Trip Unit. Adjustments for high and low gross failure levels, trip reset differential, trip output logic, and trip status output/LED logic are contained on the Slave Unit's circuit board (see Section III).

Slave Trip Units are never directly connected to any external signal source, and do not generate analog output signals.

The Slave Trip Unit is shown in Figure 3.

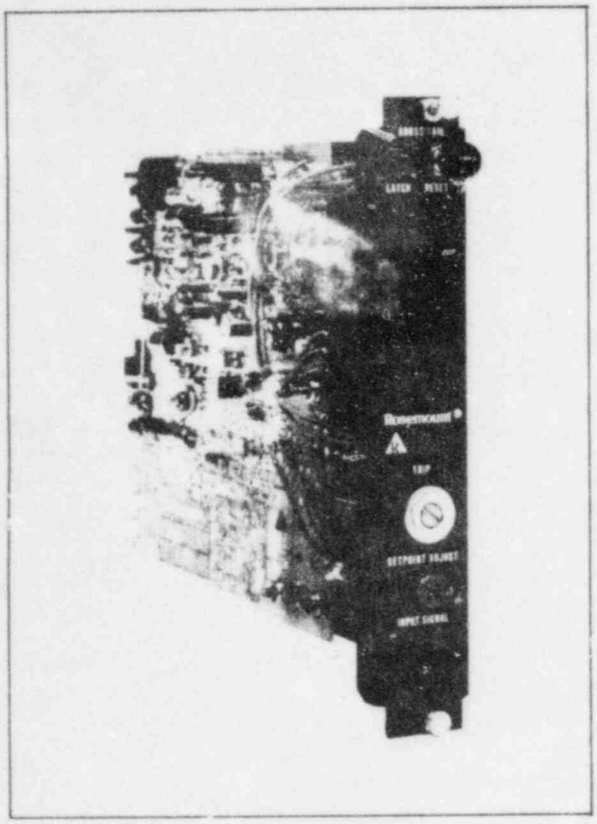


Figure 3. 710DU Slave Trip Unit.

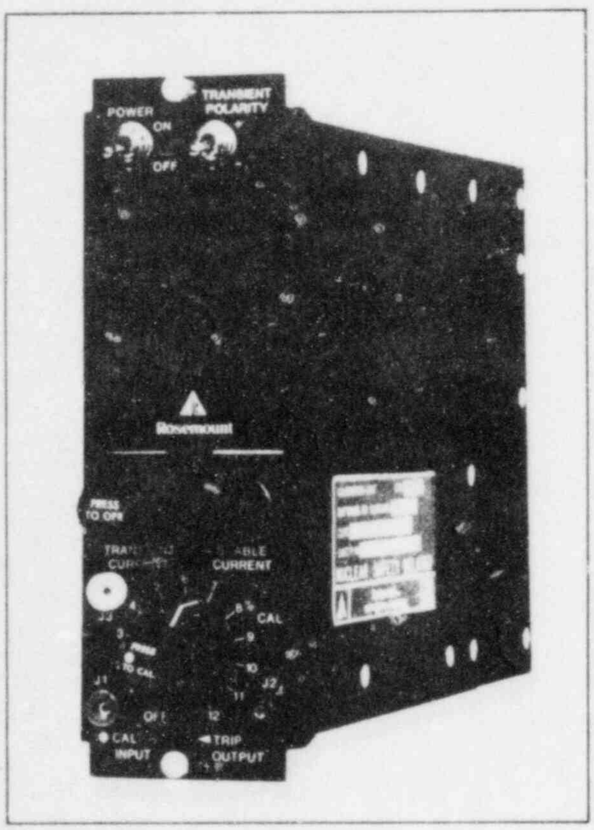


Figure 4. 710DU Calibration Unit.

Calibration Unit

All Master and Slave Trip Units in the 710DU System can be checked or adjusted in place (in the Card File) by the Calibration Unit, which produces a calibrate command signal, calibration current, and a calibration status signal. Figure 4 shows the Calibration Unit.

Calibration of any channel (Master or Slave Trip Unit) is initiated by the calibrate command signal from the Calibration Unit to a Master Trip Unit. The signal enables the Master Trip Unit to accept calibration current in place of the input signal and causes the Master Trip Unit gross failure output to generate a high (+24 Vdc) output signal.

The calibration current supplied by the Calibration Unit is made up of independently adjustable stable and transient current sources. The stable current is used to verify or adjust trip points on any of the 12 channels (Trip Units) in the Card File, and to check analog signals of Master Trip Units. The transient current is added to or subtracted from the stable current (depending on the logic selected) to provide a step current for checking time response characteristics of the Trip/Calibration System, equipment driven by the 710DU, or verifying high/low gross failure set points. The 24 Vdc calibration status signal generated by the Calibration Unit can be used for remote display/indication.

A two-part selector switch on the front panel of the Calibration Unit is used to (1) select the Master or Slave Trip Unit whose trip point is to be verified or calibrated; (2) route the calibration current to the appropriate Master Trip Unit; and, (3) activate the calibrate command signal. The front panel also includes an on/off power switch, transient current polarity switch, stable current amplitude adjustment, transient current amplitude adjustment/on off switch, and a calibration status LED. Three test jacks provide access to the transient trigger signal, signal return, and trip status signal.

The Calibration Unit provides both a mechanical support and an electrical connection for the Readout Assembly via a spring-loaded door.

Readout Assembly

The Readout Assembly (Figure 5) is a portable measurement and display device which is inserted in the front of the Calibration Unit, and can be transferred to any other Calibration Unit in the 710DU Trip/Calibration System.

The Readout Assembly contains two four-digit displays which measure and display calibration currents with a 0.01 mA resolution. The lower display, designated the calibration current display, continuously shows the total calibration current generated by the Calibration Unit.

The upper display, designated the trip current display, tracks the stable calibration current shown on the lower display until the trip output of the Master or Slave Trip Unit being calibrated changes state. The calibration current reading at that point is latched on the trip current display by the trip status signal from the Master or Slave Trip Unit. The trip current display is blanked when transient current is energized.

A trip status LED on the front of the Readout Assembly indicates when the trip current display is latched. A trip current display reset button reverses the latching logic for the trip current display and trip status LED so trip current can be read for reversed trip status logic.

The zero adjustment and span adjustment of the Readout Assembly can be made via potentiometers located near the rear of the unit (see Figure 11).

Figure 5. 710DU Readout Assembly.

SECTION II
SPECIFICATIONS

INTRODUCTION

This section of the manual contains operating specifications for the 710DU Trip/Calibration System. Mechanical, electrical, environmental, and performance specifications are detailed for the complete 710DU System, as well as for each unit/assembly included in the System. For unique characteristics of any particular 710DU System, refer to the applicable Rosemount Specification Control Drawing.

710DU SYSTEM SPECIFICATIONS

DIMENSIONS: See Table 1.

WEIGHT: See Table 2.

TABLE 1

710DU DIMENSIONS

Unit/Assembly	Height		Width		Depth	
	Inches	Centimeters	Inches	Centimeters	Inches	Centimeters
Card File	6-31/32	17.70	19	48.26	11	27.94
Master Trip Units	6-31/32	17.70	1-3/16	3.02	9-7/8	25.08
Slave Trip Unit	6-31/32	17.70	1-3/16	3.02	9-7/8	25.08
Calibration Unit	6-31/32	17.70	2-5/16	5.87	10	25.40
Readout Assembly	2-5/8	6.67	2	5.08	7-1/2	19.05

TABLE 2

710DU WEIGHT

Unit/Assembly	Pounds	Kilo-grams
Card File	6.69	3.04
Master Trip Unit with RTD Input	1.13	.51
Master Trip Unit with 4-20 mA Input	1.19	.54
Slave Trip Unit	.75	.34
Calibration Unit	2.50	1.14
Readout Assembly	1.56	.71

MOUNTING:

Card File: The Card File fits in a standard 19-inch relay rack and includes provisions for installing a tamper-proof bar over the setpoint adjustments on the Master and Slave Trip Units.

File Assignment: Master and Slave Trip Units mount in Card File locations 1 through 12 (left to right as viewed from front of Card File), the Calibration Unit in location 13 (far right). NOTE: Trip Units cannot be inserted in location 13, and the Calibration Unit cannot be inserted in locations 1 through 12.

Mechanical Support:

TRIP AND CALIBRATION UNITS: Each Master, Slave, or Calibration Unit is secured in the Card File by two captive screws, top and bottom printed circuit board guides, and a rear edge card connector(s). (See Card File specifications, and the "Wiring and Installation" section of this manual for detailed mounting instructions, and for terminal assignments for edge card connectors.)

READOUT ASSEMBLY: The Readout Assembly plugs into the Calibration Unit through a spring-loaded door. Electrical connection is made through a blind mated DA-15 connector pair.

INSTRUMENT PANEL FINISH:

All instrument panel fronts are black lusterless polyurethane paint (American Coatings and Chemicals No. 37038) with white lettering.

CIRCUIT BOARD MARKING:

Components, adjustment positions, and terminals on all printed circuit boards are identified by silk-screening or photoetching.

Electrical Specifications

POWER SUPPLY VOLTAGE REQUIREMENTS:

22.0 to 28.0 Vdc.

WARNING

Extreme caution should be exercised when operating at low power supply voltages. Some transmitters may require more voltage for proper operation at severe low or high temperature conditions. If these conditions exist when transmitter lead resistance is at the maximum value allowed and the transmitter is at a maximum current operating point (20 mA), the resulting low voltage available at the transmitter may cause it to operate improperly, and a desired trip may not occur. See Table 3 for voltages available for transmitter operation.

CURRENT DRAIN (worst case exclusive of output loads):

Master Trip Units: (4-20 mA Input & RTD Input) 260 mA, including 20mA transmitter current.

Slave Trip Unit: 225 mA.

Calibration Unit: 140 mA.

Readout Assembly: 475 mA.

OUTPUTS:

24 Vdc nominal for each trip output and gross failure output;

12 Vdc nominal for each trip status output;

24 Vdc nominal calibration status signal for remote indication;

1 to 5 Vdc analog signals proportional to input signal.

TABLE 3

VOLTAGES AVAILABLE FOR TRANSMITTER OPERATION

Power Supply Voltage	Voltage Available at Terminals 14 and 15 of Card File	Maximum Transmitter Lead Resistance for 20 mA Operating Point, and Transmitter Requiring 15.0 Vdc to Operate (Ohms)	Maximum Lead Length for Size 16 AWG Copper Wire at 20°C* (Feet)
22.0	15.32	16	3,820
23.0	16.32	66	15,700
24.0	17.32	116	27,700
25.0	18.32	166	39,700
26.0	19.32	216	51,600

*See Table 4 for maximum dc resistance of copper wire for various AWG sizes.

TABLE 4

COPPER WIRE, DC RESISTANCE
(Per ASTM Specification B1-56)

AWG Size	DC Resistance at 20°C Maximum Ohms per 1,000 Feet
8	0.824
10	1.04
12	1.65
14	2.63
16	4.18
18	6.64
20	10.50

TRIP OUTPUT LOGIC:

Normal trip output logic provides a 24 Vdc output when input signal is greater than the trip point. Reversed trip output logic provides a 24 Vdc output when input signal is less than the trip point. Trip output logic is indicated by NORM and REV at the trip output logic switch on the printed circuit board (Figure 8).

TRIP STATUS LED LOGIC:

Normal trip status logic provides a 12 Vdc output and trip status LED on when trip output is 24 Vdc. Reversed trip status logic provides a 12 Vdc output and trip status LED on when trip output is 0 Vdc. Trip status logic is indicated by NORM and REV at the trip status LED logic switch on the printed circuit board (Figure 8).

Accompanying Instrumentation

RELAYS:

Relays should be selected and supplied by the customer in accordance with specific environmental requirements.

INPUT SENSORS:

Transmitters: Two-wire or 4-wire, 4-20mA transmitters are required, and should be purchased by the customer according to particular requirements. Rosemount's line of Model 1152 and 1153 Pressure Transmitters are qualified for use in Nuclear Power Generating Stations.

Resistance Temperature Detectors (RTD's): Shielded, 3-wire, platinum RTD's with $R_0 = 100$ ohms are required and should be purchased by the customer according to particular requirements.

CABINET:

A standard 19-inch rack for housing the 710DU System, power supplies, and relays should be supplied by the customer. Location of the cabinet at the customer site should be such that the resistance of the wire used to make connections between the 710DU System and the transmitters does not exceed 16 ohms. This assures a minimum turn-on voltage for the transmitters of 15.0 Vdc when the power supply is at a minimum value of 22.0 Vdc.

Environmental Specifications

ENVIRONMENTAL CONDITIONS: See Table 5.

SEISMIC VIBRATION:

The Card File, Master Trip Units, and Slave Trip Units operate during and after exposure to seismic vibration with a ZPA of 1.17 g OBE and 1.75 g SSE. See Rosemount Report D8200037.

ELECTROMAGNETIC SUSCEPTIBILITY:

The 710DU operates in EMI conditions normally expected in a power plant control room environment, provided that shielded wires are used for all signal connections and the auxiliary analog output.

TABLE 5

ENVIRONMENTAL CONDITIONS

Operating Condition		Normal	Transient	Accident (Includes Margin)
Temperature	°F	60 to 90	160 for 24 hours once per year	185° for 6 hours
				150° for 8 hours
	°C	15 to 32	71 for 24 hours once per year	85° for 6 hours
				65.6° for 8 hours
Relative Humidity		40 to 50%	90% for 24 hours once per year	90% for 14 hours
Radiation		$\leq 10^5$ Rad (air) TID over 20 years		2×10^5 Rad (air) TID in 24 hours
Power Supply		22 to 28 Vdc		

CARD FILE SPECIFICATIONS

General

The following specifications apply to the 710DU Card File.

Mechanical Specifications

CONSTRUCTION:

The Card File is constructed to mount in a standard 19-inch relay rack. Mechanical support for Master Trip Units, Slave Trip Units, and a Calibration Unit is provided by aluminum cross members. Printed circuit board guides are attached to the cross members to ensure proper alignment between the Card File connector and the Master or Slave Trip Unit installed; or, in the case of the Calibration Unit, between the two Card File connectors and the Calibration Unit.

Electrical Specifications

TRIP UNIT CONNECTIONS:

The Card File provides an electrical connection for a Master or Slave Trip Unit through a single-sided edge card connector with gold-plated contacts. External connections (power supply, relays, recording equipment, etc.) are made to the connector with 6-32 x ½-inch cadmium-plated, steel screws. Each connector has a dielectric strength of 1500 volts, while each terminal has a maximum rating of 5 amps.

CALIBRATION UNIT CONNECTIONS:

Card File connections to the Calibration Unit are made through both single-sided and double-sided edge card connectors. Both connectors have a dielectric strength of 1500 volts, and a maximum rating of 5 amps for each terminal.

CARD FILE WIRING:

Power bus bars are used to make connections across terminals 1 and 2 (see Rosemount Specification Control Drawing for details). Connections between terminals 5, 6 and 7 are made using stranded, silicone rubber-insulated, tin-coated, copper conductors. (A Card File is shown in Figure 24. More details are included in the "Wiring and Installation" section.)

MASTER TRIP UNIT SPECIFICATIONS

General

The following specifications apply to all Master Trip Units in the 710DU Trip/Calibration System.

Mechanical Specifications

CONSTRUCTION:

The Master Trip Unit can be removed from the Card File or reinserted when power is applied without damage to any electronic components.

METER:

The customer must specify required meter labeling and scaling.

Electrical Specifications

INPUT INTERFACE:

Transmitter Signal: A 4-20 mA transmitter signal is required for proper operation of the 4-20 mA Input Master Trip Unit. Total transmitter loop resistance exclusive of transmitter and leadwires is 330 ohms (nominal). The transmitter loop is current limited to less than 100 mA. A short circuit condition (terminals of transmitter shorted to ground or together) may persist indefinitely with no damage to the Master Trip Unit.

Input Signal Test Jack (4-20 mA): Test jack J1 on the Master Trip Unit's front panel monitors transmitter current to the Master Trip Unit. Input current is fed through a 250 ohm precision resistor to generate a 1-5 Vdc signal at this jack.

RTD Signal: A shielded, 3-wire, platinum RTD with R_0 = 100 ohms is required for proper operation of the RTD Input Master Trip Unit. The RTD leads may be shorted to ground or together with no damage to the Master Trip Unit.

Input Signal Test Jack (RTD Input): Test jack J1 on the RTD Input Master Trip Unit's front panel monitors the buffered bridge output. This signal is 1-5 Vdc proportional to the resistance of the RTD when the zero, span, and linearity adjustments are set to the required values for the temperature range being monitored.

TRIP OUTPUT AND GROSS FAILURE OUTPUT:

Each output is +24 Vdc nominal for logic level 1 and

less than +1 Vdc for logic level 0. Either output is capable of driving a resistive load of 24 ohms and up, or an inductive load of up to 4 Henries. Two or more trip outputs or gross failure outputs can drive the same load.

ANALOG OUTPUTS:

Two analog signals are provided by Master Trip Units. One signal drives Slave Trip Units. The analog voltage level for this output is factory-adjusted to meet the requirements of the Slave Trip Unit input. The second (auxiliary) analog signal is for resistive loads such as recorders, meters, or controllers. The auxiliary analog output voltage level is 1 to 5 Vdc. The frequency response of the auxiliary analog output can be adjusted to provide a break frequency between 0.8 and 8.0 Hz on 4 to 20 mA Input Master Trip Units, only.

ANALOG OUTPUT TO SLAVE TRIP UNITS:

Load: Up to seven Slave Trip Units can be driven by the analog signal from a single Master Trip Unit without affecting the performance of the Master Trip Unit.

Voltage Range: Analog output is 0 to 10 Vdc corresponding to a current input of 0 to 40 mA. The calibrated range, over which the accuracies of Table 6 apply, is 1 to 5 Vdc corresponding to a 4 to 20 mA transmitter input, or 0-100% of span for RTD Input Trip Units.

Frequency Response: The analog signal to Slave Trip Units has a second order break frequency at 250 Hz.

AUXILIARY ANALOG OUTPUT:

Load: The auxiliary analog output signal is capable of driving resistive loads from 1,500 ohms and up.

Voltage Range: Analog output is 0 to 10 Vdc corresponding to a 0 to 40 mA current input. The calibrated range, over which the accuracies of Table 6 apply, is 1 to 5 Vdc corresponding to a transmitter input of 4 to 20 mA or 0 to 100% of span for RTD Input Master Trip Units.

Frequency Response: (4-20 mA Input option only): Auxiliary analog output frequency response is determined by a second order break filter adjustable from 0.8 to 8.0 Hz.

Output Signal Test Jack: Test jack J2 on the Master Trip Unit's front panel is used to monitor the auxiliary analog output signal.

Input-Output Isolation: Auxiliary analog output is isolated to the extent that trip function accuracy is not affected by:

1. Output shorted to power supply return or chassis ground;
2. Output shorted to +24 Vdc (Master Trip Unit power supply);
3. Output shorted to +125 Vdc;
4. Output shorted to +115 Vac;
5. Output disconnected from the load.

MASTER TRIP UNIT/CALIBRATION UNIT INTERFACE:

The following signal interfaces are used only when the Master Trip Unit is being calibrated:

1. **Calibration Current:** 0 to 41 mA current generated in the Calibration Unit which is used to check functions or perform calibration of the Master Trip Unit.
2. **Calibrate Command:** 24 Vdc signal from the Calibration Unit to the Master Trip Unit which actuates a DPDT relay to substitute calibration current for the input signal. Calibrate command also causes the gross failure output on the Master Trip Unit to indicate that it is inoperative during calibration.
3. **Trip Status Signal:** 0 to 12 Vdc nominal logic signal from the Master Trip Unit to the Calibration Unit which changes state with the trip output signal. The trip status signal latches the trip current display on the Readout Assembly at the trip point of the Master Trip Unit.

TABLE 6

ANALOG OUTPUT ACCURACY
Master Trip Unit

Operating Condition	Analog Output Accuracy
Normal	± 0.15% (60° to 90°F) ± 0.35%/100°F

Performance Specifications

ANALOG OUTPUT ACCURACY:

The accuracy of both analog outputs is shown in Table 6. Output accuracy is defined as an allowable deviation (percent of span) from the ideal input-output function. Requirements are specified for normal operating conditions (see Table 5). The analog output accuracy requirements listed are valid for up to six months of operation.

TRIP POINT REPEATABILITY:

See Table 7. Repeatability is based on an input signal of 4 to 20 mA (equivalent to 10 to 50% of span), or equivalent RTD resistance. (See Table 5 for definition of plant operating conditions.) The trip point repeatability requirements listed are valid for up to six months of operation.

TABLE 7

TRIP POINT REPEATABILITY
Master Trip Units

Operating Condition	Trip Output Repeatability
4-20 mA Input Normal	±0.13% (60° to 90°F) ±0.20%/100°F
RTD Input Normal	±0.75% (60° to 90°F) ±1.5%/100°F
4-20 mA Input Accident	±0.40%
RTD Input* Accident	±2.0%

*Fully ranged down.

SLAVE TRIP UNIT SPECIFICATIONS

General

The following specifications apply to all Slave Trip Units in the 710DU Trip/Calibration System.

Mechanical Specifications

CONSTRUCTION:

The Slave Trip Unit can be removed from the Card File or reinserted when Power is applied, without damage to any electronic components.

Electrical Specifications

MASTER TRIP UNIT INTERFACE:

Slave Trip Units are driven by a 0 to 10 Vdc analog signal (calibrated from 1 to 5 Vdc) from a Master Trip Unit. This signal is monitored by Test Jack J1 on the front panel of the Slave Trip Unit. Up to seven Slave Trip Units may be connected to a single analog-to-Slave signal.

TRIP OUTPUT AND GROSS FAILURE OUTPUT:

Each output is +24 Vdc nominal for logic level 1 and less than +1 Vdc for logic level 0. Either output is capable of driving a resistive load from 24 ohms and up, or an inductive load of up to 4 Henries. Two or more trip outputs or gross failure outputs can drive the same load.

SLAVE TRIP UNIT/CALIBRATION UNIT INTERFACE:

The only active interface signal when the Slave Trip Unit is being calibrated is:

1. **Trip Status Signal:** 0 to 12 Vdc nominal logic signal from the Slave Trip Unit to the Calibration Unit which changes state with the trip output signal. The trip status signal latches the trip current display on the Readout Assembly at the trip point of the Slave Trip Unit.

Performance Specifications

TRIP POINT REPEATABILITY:

See Table 8. Repeatability is based on a 4 to 20 mA input signal (equivalent to 0 to 100% of span). Performance is specified for normal and accident plant operating conditions (see Table 5). The trip point repeatability requirements listed are valid for up to six months of operation when driven by a properly functioning Master Trip Unit.

TABLE 8

TRIP POINT REPEATABILITY
Slave Trip Unit

Operating Condition	Trip Output Repeatability
Normal	±0.20% (60° to 90°F) ±0.35%/100°F
Accident	±0.60%

CALIBRATION UNIT SPECIFICATIONS

General

The following specifications apply to the 710DU Calibration Unit.

Electrical Specifications

TRIP UNIT INTERFACE:

1. **Stable Calibration Current:** The Calibration Unit produces a stable, independently adjustable current which is used to calibrate Master or Slave Trip Unit trip points, or verify analog outputs.

   STABLE CALIBRATION RANGE: 3.5 to 20.5 mA.

   RAMP RATE: Maximum rate of change of stable calibration current is 1.0 ± 0.1 mA per second.

   STABILITY: Once set, stable calibration current will not vary more than ± 5 microamps for normal operating conditions.

2. **Transient Calibration Current:** The Calibration Unit produces an independently adjustable step (transient) current which is added to, or subtracted from the stable current. Transient current may be used to check response time of Master and Slave Trip Units or external equipment driven by the 710DU System, and also to verify gross fail points.

   TRANSIENT CALIBRATION CURRENT RANGE: 0.5 to 20.5 mA. Addition or subtraction is determined by a switch on the Calibration Unit's front panel labeled Polarity.

   RISE AND FALL TIME: The rise and fall time of transient calibration current in response to the transient current amplitude adjustment or transient polarity switch is less than 100 microseconds between 10 and 90%, or 90 and 10% of final value.

   STABILITY: Once set, transient calibration current will not vary more than +50 microamps for normal plant operating and environmental conditions.

3. **Calibration Current:** Calibration current is the total current (0 to 41 mA) routed to a Master Trip Unit. Calibration current can be (1) stable calibration current only, or (2) stable current added to transient calibration current, or (3) the difference between stable and transient currents. If the transient current is used as a negative value it cannot force the sum of the transient and stable currents to a value less than 0.0 mA.

4. **Calibrate Command:** Calibrate command is a 24 Vdc signal to a Master Trip Unit which actuates a DPDT relay to substitute calibration current for the input signal.

5. **Trip Status Signal:** The Calibration Unit receives a trip status signal (12 Vdc for logic level 1 and 0 Vdc for logic level 0) from the Master or Slave Trip Unit being calibrated. The signal latches the trip current display on the Readout Assembly at the trip point of the Master or Slave Trip Unit.

6. **Calibration Status Signal:** When energized, the Calibration Unit produces a 24 Vdc signal capable of driving a resistive load of 75 ohms and up, and an inductive load of up to 0.8 Henries. The signal provides for remote status indication that a Trip Unit is being calibrated.

7. **Transient Blanking Signal:** When transient calibration current is activated, the transient blanking signal blanks the trip current display on the Readout Assembly.

READOUT ASSEMBLY CONNECTIONS:

Signals provided at the Readout Assembly connector are:

1. Chassis ground,
2. +24 Vdc power
3. Display engaged,
4. +24 Vdc power return,
5. Calibration current return,
6. Calibration current,
7. Trip status output,
8. Transient blanking.

TEST JACKS:

Three test jacks on the Calibration Unit's front panel access the:

1. Transient trigger signal (J1),
2. Signal return (J2),
3. Trip status signal (J3).

READOUT ASSEMBLY SPECIFICATIONS

General

The following specifications apply to the 710DU Readout Assembly.

Electrical Specifications

CALIBRATION UNIT CONNECTIONS:

The following signals, plus power, power return, and chassis ground comprise the connections:

1. **Calibration Current:** The total calibration current generated by the Calibration Unit is brought into the Readout Assembly for measurement and display.
2. **Calibration current return.**
3. **Trip Status:** The signal from the Master or Slave Trip Unit being calibrated for trip point setting is brought to the Readout Assembly and used to latch the trip current display.
4. **Display Engaged:** This return signal for a relay drive circuit in the Calibration Unit causes the calibration current to be routed to the Readout Assembly.
5. **Transient Blanking:** This logic level is tied to the transient current switch on the Calibration Unit, and causes the trip current display to be blanked when transient current is activated.

Performance Specifications

RESOLUTION:

The Readout Assembly will measure and display calibration current with a 0.01 mA resolution during normal operating conditions. The operating temperature range of the Readout Assembly is 40 to 104°F (4.44 to 40.00°C).

SECTION III
ADJUSTMENTS AND DISPLAYS

INTRODUCTION

Tables 9, 10, and 11 contain functional descriptions of the front panel and printed circuit board adjustments and displays required for proper operation of the 710DU Trip/Calibration System. Figures 6, 7, 8, 9, 10, and 11 show the locations of all items included in the tables.

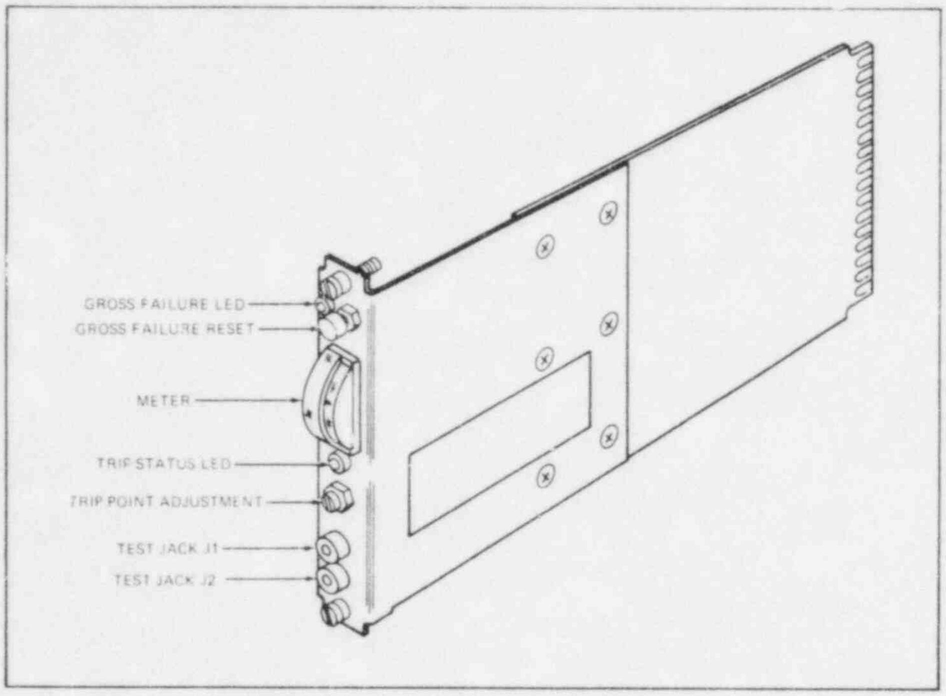


Figure 6. Master Trip Unit — Front Panel Adjustments and Displays

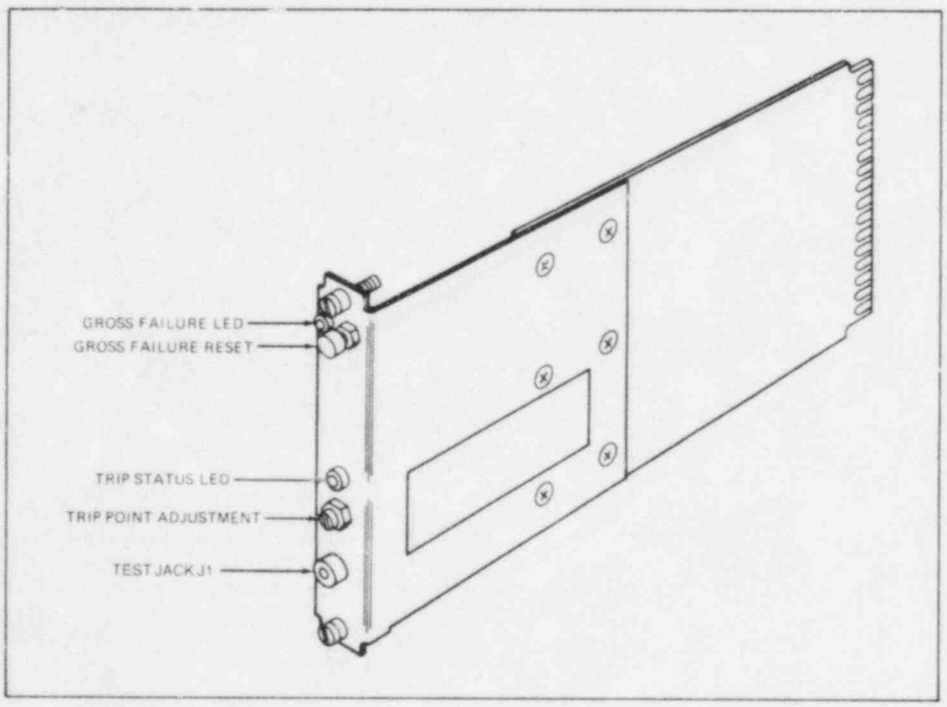
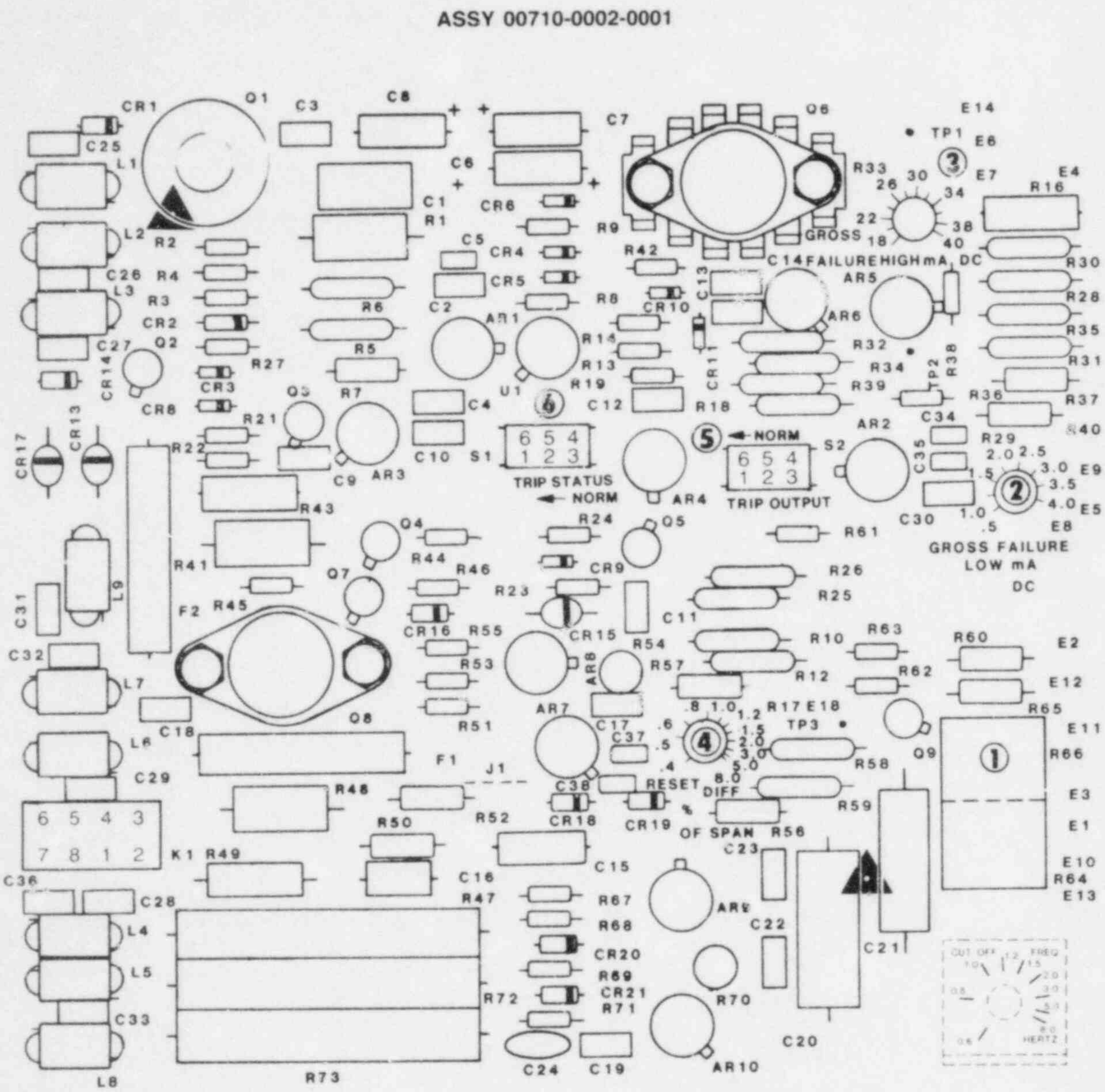


Figure 7. Slave Trip Unit — Front Panel Adjustments and Displays.



1. FREQUENCY RESPONSE ADJUSTMENT
2. LOW GROSS FAILURE ADJUSTMENT
3. HIGH GROSS FAILURE ADJUSTMENT
4. RESET DIFFERENTIAL ADJUSTMENT
5. TRIP OUTPUT LOGIC SWITCH
6. TRIP STATUS OUTPUT/LED LOGIC SWITCH

Figure 8. 4-20 mA Input Master Trip Units and Slave Trip Units Circuit Card Assy Adjustments.

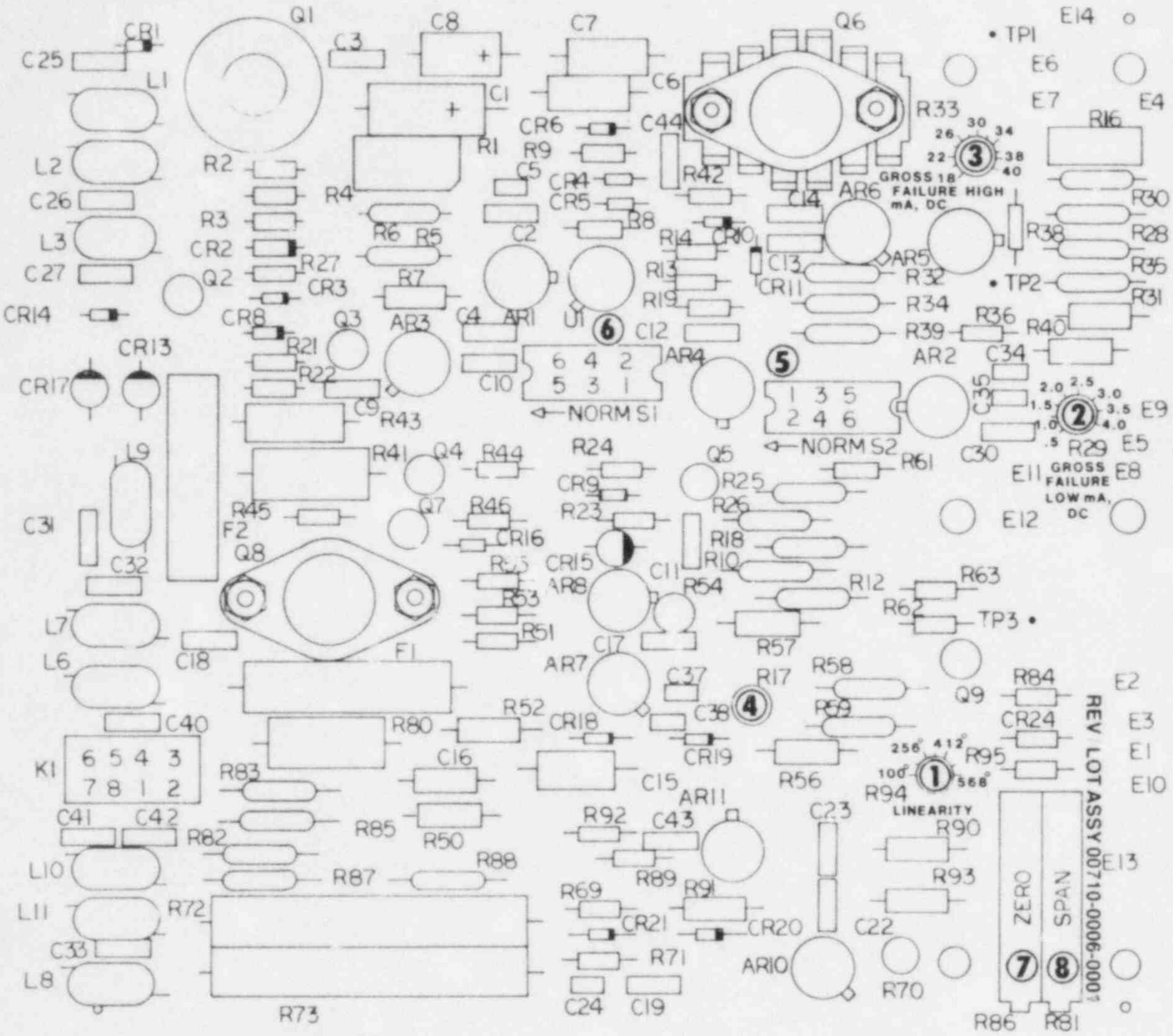
TABLE 9

ADJUSTMENTS AND DISPLAYS

710DU Master and Slave Trip Units

Adjustment/ Display	Included On: 4-20 mA Master Trip	RTD Input Master Trip	Slave Trip	Location	Function
Reset Differential	Yes	Yes	Yes	Circuit Card Assy (Figure 8)	Single-turn potentiometer provides for adjusting the reset differential from a minimum of 0.5% to a maximum of 7.5% of the input span.
Frequency Response Adjustment*	Yes	No	No	Circuit Card Assy (Figure 8)	Single-turn potentiometer is used to adjust break frequency (0.8 to 8.0 Hz) of auxiliary analog output signal.
Low Gross Failure Adjustment*	Yes	Yes	Yes	Circuit Card Assy (Figure 8)	Single-turn potentiometer allows low gross failure trip point to be set between 0.5 and 4.0 mA. Gross failure output is high (logic level 1) when transmitter current falls below the low gross failure setting.
High Gross Failure Adjustment*	Yes	Yes	Yes	Circuit Card Assy (Figure 8)	Single-turn potentiometer allows high gross failure trip point to be set between 19.5 and 40 mA. Gross failure output is high (logic level 1) when transmitter current exceeds the high gross failure setting.
Trip Output Logic Switch*	Yes	Yes	Yes	Circuit Card Assy (Figure 8)	Switch determines the logic of the trip output to be high (logic level 1) either above or below the trip point. Normal and reversed trip output logic are defined in the "Specifications" section.
Trip Status Output/LED Logic Switch*	Yes	Yes	Yes	Circuit Card Assy (Figure 8)	Switch determines the logic of the trip status LED so that the LED is either on or off when the trip output is high. Normal and reversed trip status output/LED logic are defined in the "Specifications" section.
Trip Point Adjustment	Yes	Yes	Yes	Front Panel (Figures 6 and 7)	Ten-turn screw type potentiometer provides for setting the trip point anywhere in the 4 to 20 mA range, with a resolution of 0.01 mA.
Gross Failure Reset	Yes	Yes	Yes	Front Panel (Figures 6 and 7)	Momentary push button switch resets the latching gross failure output and indication LED.
Gross Failure LED	Yes	Yes	Yes	Front Panel (Figures 6 and 7)	Red LED comes on when a gross failure is detected and stays on until reset.
Trip Status LED	Yes	Yes	Yes	Front Panel (Figures 6 and 7)	Red LED displays the trip output level according to the logic selected.
Meter	Yes	Yes	No	Front Panel (Figure 6)	Meter displays the input signal from a 4 to 20 mA transmitter with ± 2% accuracy.
Test Jack J1 (Red)	Yes	Yes	Yes	Front Panel (Figure 6)	J1 is used to monitor the sensor input signal to the Master Trip Units. J1 is used on the Slave Grip Unit to monitor its input signal. Reference J2 on the Calibration Unit.
Test Jack J2 (White)	Yes	Yes	No	Front Panel (Figure 6)	J2 is used to monitor the optional auxiliary analog output signal. Reference J2 on the Calibration Unit.
Zero Adjust*	No	Yes	No	Circuit Card Assy (Figure 9)	Adjust Zero Point (32°F minimum to 500°F maximum)
Span Adjust*	No	Yes	No	Circuit Card Assy (Figure 9)	Adjust Span (100°F minimum to 568°F maximum)
Linearity Adjust*	No	Yes	No	Circuit Card Assy (Figure 9)	Compensate for non-linearities of the RTD over the selected span.

*These adjustments should be made before the 710DU is put in operation.



1. LINEARITY ADJUSTMENT
2. LOW GROSS FAILURE ADJUSTMENT
3. HIGH GROSS FAILURE ADJUSTMENT
4. RESET DIFFERENTIAL ADJUSTMENT
5. TRIP OUTPUT LOGIC SWITCH
6. TRIP STATUS OUTPUT/LED LOGIC SWITCH
7. ZERO ADJUSTMENT
8. SPAN ADJUSTMENT

Figure 9. RTD Input Master Trip Unit — Circuit Card Assy Adjustments.

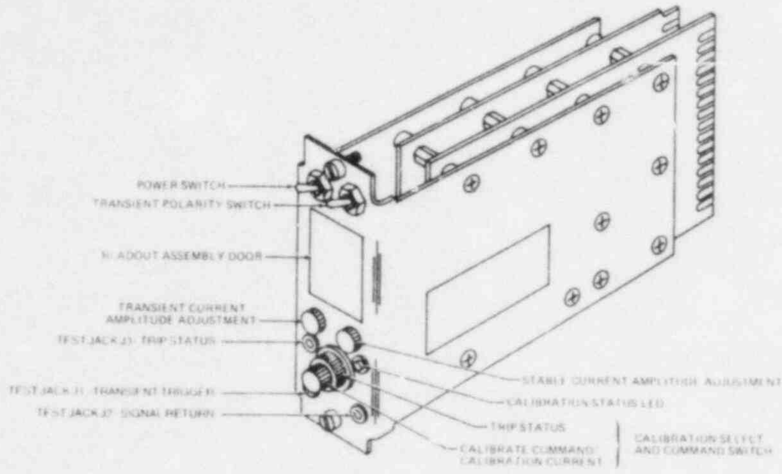


Figure 10. Calibration Unit — Adjustments and Displays.

TABLE 10

ADJUSTMENTS AND DISPLAYS

710DU Calibration Unit (See Figure 10)

Adjustment/Display	Function
Power Switch	ON/OFF switch controls the application of 24 Vdc power to the Calibration Unit and Readout Assembly.
Readout Assembly Door	The removable Readout Assembly plugs into the Calibration Unit through the spring-loaded door.
Calibration Select and Command Switch	Two-part rotary and push/pull switch has three calibration select and control functions. The smaller (center) knob selects the Master Trip Unit to which the calibrate command/calibration current is routed and, when pushed in, activates the calibrate command/calibration current. The larger (outer) knob selects the Master or Slave Trip Unit whose trip status is being monitored. Both knobs have 12 active (address) positions and an off position. The smaller knob is locked (cannot be rotated) when pushed in. The larger knob can be rotated at all times.
Transient Current Amplitude Adjustment	Single-turn push/pull potentiometer is used to set and engage the transient calibration current. With the potentiometer pushed in, transient current can be adjusted from 0.5 to 20.5 mA, and added to or subtracted from the stable calibration current — depending on the position of the Transient Polarity Switch. When the potentiometer is pulled out, transient current is disengaged.
Transient Polarity Switch	Positive/negative switch enables the transient current to be added to or subtracted from the stable calibration current.
Stable Current Amplitude Adjustment	Ten-turn potentiometer is used to adjust the stable calibration current through a 3.5 to 20.5 mA range.
Calibration Status LED	Red LED is lighted when the smaller (center) knob of the Calibration Select and Command Switch is pushed in.
Test Jack J1 (Red)	J1 is used to trigger an oscilloscope to measure time response characteristics of the 710DU System, or the time response of equipment controlled by the 710DU System.
Test Jack J2 (Black)	J2 provides an output for the signal return. This is the reference point for all voltage measurements on Trip Units.
Test Jack J3 (White)	J3 provides a test point for the trip status output which is used to measure the time response of the trip output.

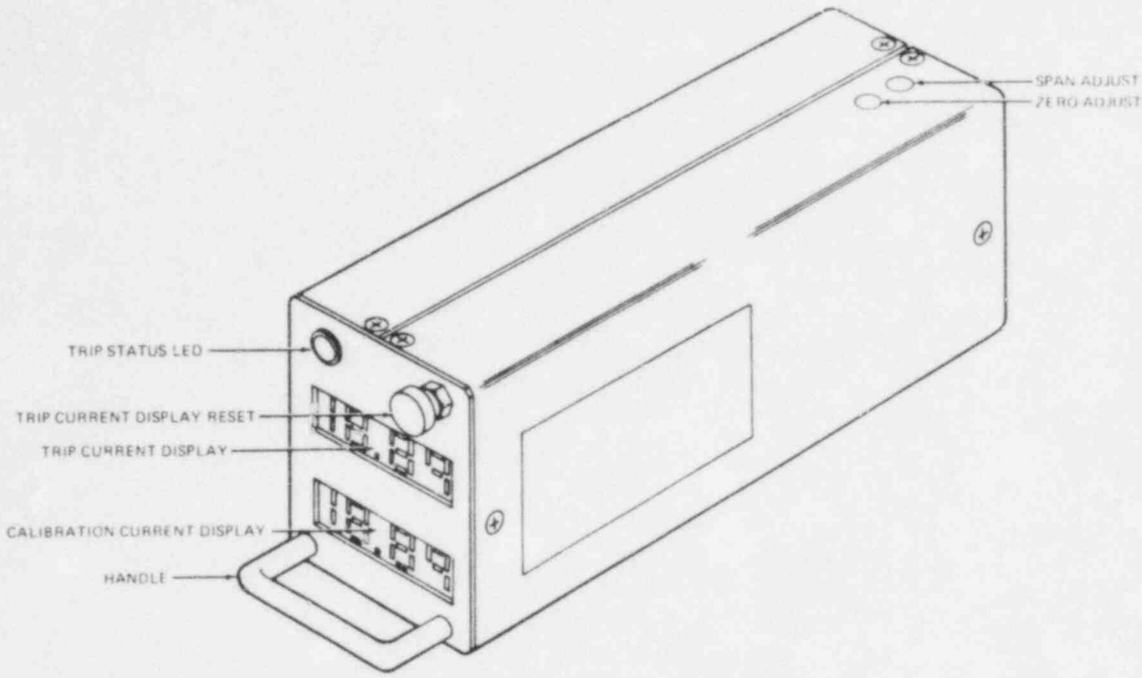


Figure 11. Readout Assembly — Adjustments and Displays.

TABLE 11

ADJUSTMENTS AND DISPLAYS
710DU Readout Assembly (See Figure 11)

Adjustment/Display	Function
Calibration Current Display	Lower readout displays total calibration current generated by the Calibration Unit. Range of the display is from 00.00 to at least 45.00 mA with 0.01 mA resolution.
Trip Current Display	Upper readout tracks the stable calibration current shown on the Calibration Current Display (lower readout) until a trip occurs in the Master or Slave Trip Unit being calibrated. At that point, the trip status signal latches the Trip Current Display. The display is blanked when transient current is activated.
Trip Status LED	Red LED indicates that the Trip Current Display is latched. It must be reset before trip current can be read for reversed trip status logic.
Trip Current Display Reset	Push button switch reverses the latching logic for the Trip Current Display and Trip Status LED so trip current can be read for reversed trip status logic.
Zero Adjust	Multi-turn potentiometer is accessible through Readout Assembly housing, near rear of unit. Zero adjustment provides for an equal change in the two digital displays for both low and high value readings.
Span Adjust	Multi-turn potentiometer is accessible through Readout Assembly housing, near rear of unit. Span adjustment provides for a small change in both digital displays for low value readings, and a greater change in the displays for high value readings.
Handle	Handle provides for easy removal and insertion of Readout Assembly in Calibration Unit.

SECTION IV
THEORY OF OPERATION

INTRODUCTION

This section of the manual presents the theory of operation of the 710DU Trip/Calibration System, and includes block diagrams and other logic diagrams.

An overall description of the entire 710DU System is given first; the theory of operation for each unit or assembly in the Trip/Calibration System follows. For additional information, refer to the applicable Rosemount Specification Control Drawing.

710DU SYSTEM

The functional block diagram shown in Figure 12 illustrates the theory of operation of the 710DU System.

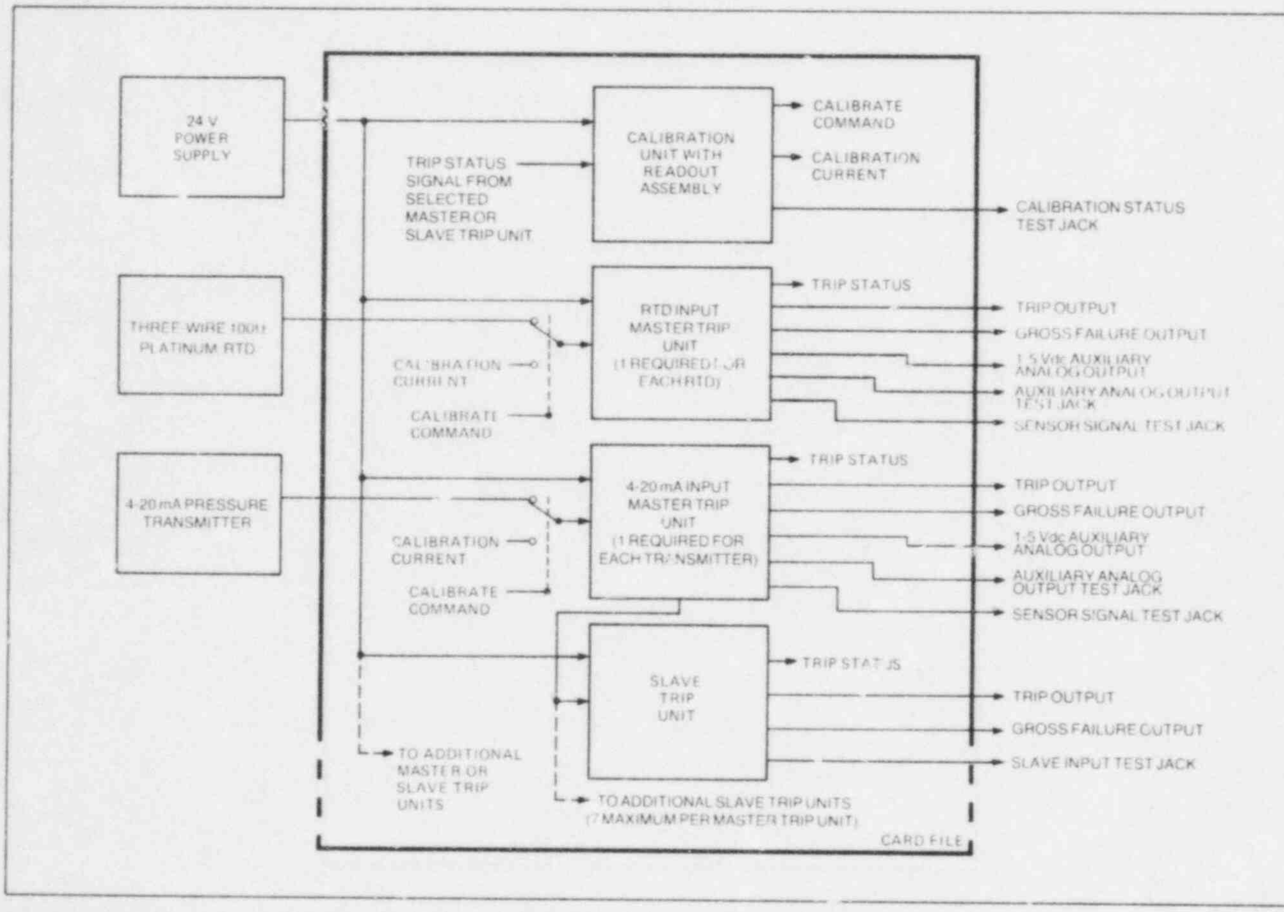


Figure 12. 710DU Trip/Calibration System Functional Block Diagram.

The 710DU Trip/Calibration System includes a Card File containing Master Trip Units, Slave Trip Units, a Calibration Unit, and a Readout Assembly. When the 710DU System is connected to a 24 Vdc power supply, and 4 to 20 mA transmitters or 3-wire platinum RTD's, easily-calibrated trip points provide trip outputs for any input signal level. The Master Trip Unit provides a latching gross failure output when the input signal drops below or exceeds low or high limits, respectively.

Master and Slave Trip Unit Operation

One Master Trip Unit is required for each sensor input. A Master Trip Unit produces two analog signals, an auxiliary signal for driving external recording or monitoring equipment, and another signal for driving up to seven Slave Trip Units. Each Slave Trip Unit adds one additional trip point and one gross failure output for the input sensor channel. LED's on each Master and Slave Trip

Unit's front panel provide visual indication of trip outputs and gross failure outputs. Master Trip Units provide an analog meter to display the input signal and a test jack (J1) to monitor that signal. The Master Trip Unit has an additional test jack (J2) to monitor the auxiliary analog output signal.

Adjustments are included on the Master and Slave Trip Unit printed circuit boards for setting the trip output logic; trip status output logic; gross failure low current trip output; gross failure high current trip output; and reset differential. The 4-20 mA Input Master Trip Units also have an adjustment for the frequency response of the auxiliary analog signal.

Calibration Unit and Readout Assembly Operation

The trip point for any Master or Slave Trip Unit in the 710DU System can be verified or accurately calibrated by the Calibration Unit and Readout Assembly. The Calibration Unit replaces the input signal with an adjustable calibration signal, which is shown on both four-digit displays of the Readout Assembly. When the calibration current passes through the trip point of the Trip Unit being calibrated, the trip status signal changes state and latches the upper display of the Readout Assembly. An LED on the Readout Assembly indicates that the display is latched. A reset button provides for reading reversed trip status logic.

A stable calibration current source is used to verify or calibrate trip points or check analog outputs. A transient calibration current source can be used with the stable current for time response measurements. The stable and transient currents can be adjusted, and a transient polarity switch enables transient current to be added to or subtracted from stable current, depending on the logic desired.

The Calibration Unit's front panel includes a two-part calibration select and command switch which initiates the calibration process, routes the calibration current to a Master Trip Unit, and selects the Master or Slave Trip Unit whose trip point is being monitored.

Test Jacks are provided for transient trigger output (J1), signal return (J2), and trip status output (J3).

The ON/OFF switch on the Calibration Unit controls power to the Readout Assembly and Calibration Unit.

CARD FILE

The Card File houses the Master Trip Units, Slave Trip Units, and the Calibration Unit, and provides electrical interface among them. The 24 Vdc power supply and input sensors are connected to the Card File, along with relays, alarms, meters, recorders, actuators, or any other loads driven by the trip output, gross failure output, or auxiliary analog output of the 710DU System.

The Card File (see Section V, "Wiring and Installation", and Figure 23) provides electrical interface between the Calibration Unit and the Master Trip Unit to which calibration current is fed; it also connects the Calibration Unit and the Master or Slave Trip Unit whose trip point is being verified or adjusted. In addition, all Trip Units and the Calibration Unit are wired for 24 Vdc power and chassis ground.

The customer must make the necessary interconnections between the Slave Trip Unit input and the analog-to-Slave signal from a Master Trip Unit.

MASTER TRIP UNIT (4-20 mA INPUT)

A functional block diagram of the 710DU Master Trip Unit is shown in Figure 13.

The Master Trip Unit mounts in any of the first 12 Card File locations; it is connected to a 24 Vdc power supply via terminals 2,3, and 4 of the Card File, and to a remote transmitter via terminals 14 and 15. The Master Trip Unit conditions a 4-20 mA signal from the transmitter providing trip output and gross failure output signals.

The 24 Vdc input is regulated to the +15 Vdc by a standard design internal power supply. The +15 Vdc supplies the positive voltage required by the operational amplifiers (used as comparators, scaling amps, or buffers) in the Master Trip Unit circuit. In addition, the +15 Vdc drives an oscillator used to generate the -4.7 Vdc (negative) power required by the operational amplifiers, and generates a +6.2 Vdc reference voltage.

The 4 to 20mA transmitter current is fed into a 250-ohm precision resistor where a 1 to 5 Vdc voltage is developed.

This voltage is buffered and filtered by a second order low pass filter with a break frequency of approximately 250 Hz; it is used in the Master Trip Unit circuit for the analog meter, and generating the trip output, trip status output, and gross failure output.

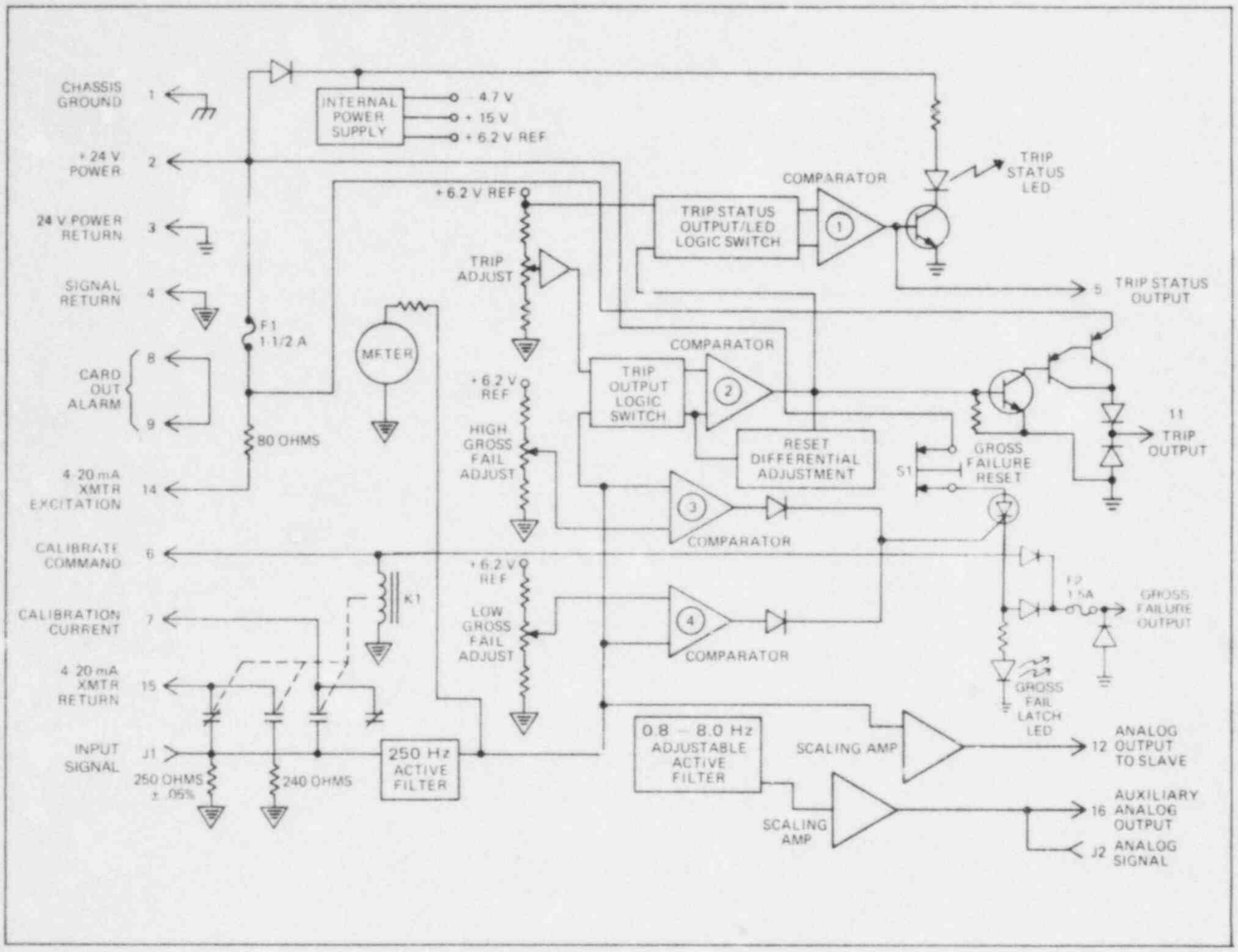


Figure 13. 4-20 mA Input Master Trip Unit Functional Block Diagram.

Analog Meter

The 1 to 5 Vdc signal drives an analog meter (accuracy of 3% of full scale) located on the Master Trip Unit's front panel. The meter provides for continuous monitoring of the transmitter loop. The analog meter is protected against short circuit current loads.

Trip Output

The 1 to 5 Vdc signal is compared by comparator (2) (see block diagram, Figure 13) with an adjustable buffered reference voltage (adjusted by a 10-turn potentiometer). If the signal does not pass through the adjustable reference voltage level, no trip action occurs. If the 1 to 5 Vdc signal passes through and becomes greater than the reference voltage, the resulting trip output changes from 0 Vdc to approximately 24 Vdc (logic level 1). By changing the position of the trip output logic switch, the logic of the trip output is reversed; i.e., trip output changes from 24 Vdc to approximately 0 Vdc (logic level 0) when the 1 to 5 Vdc signal passes through and becomes greater than the reference voltage. Figures 14 and 15 illustrate normal and reversed trip output logic.

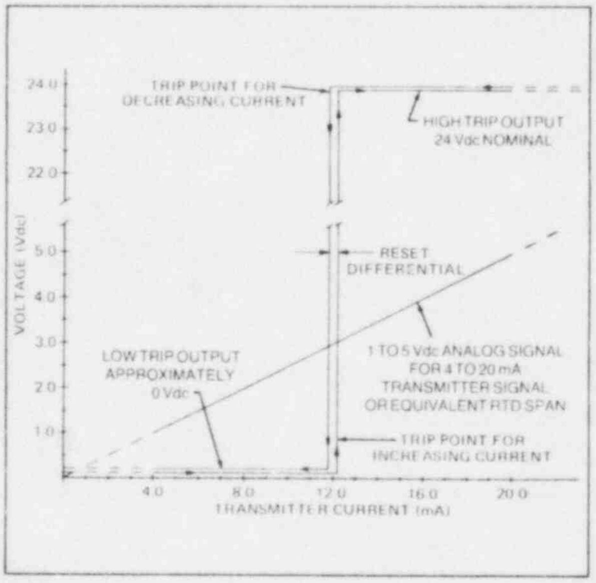


Figure 14. Trip Output — Normal Logic.

Comparator (2) has a single-turn potentiometer which can be used to adjust the reset differential of the trip point from 0.5 to 7.5% of the transmitter current span.

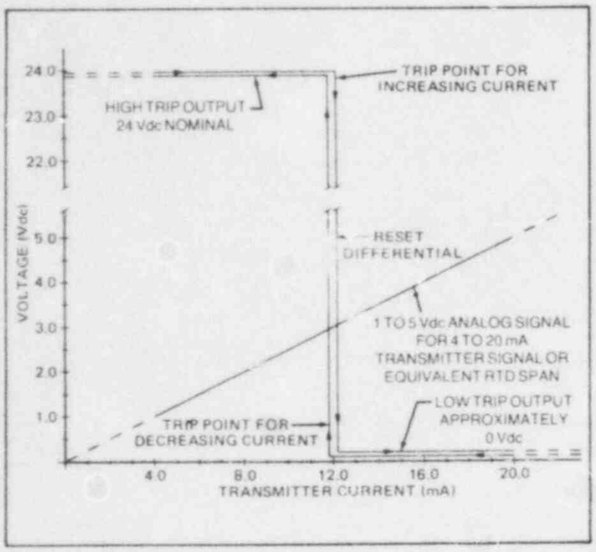


Figure 15. Trip Output — Reversed Logic.

Trip Status Output

Comparator ② output is compared with a +6.2 Vdc reference signal by comparator ① (see block diagram). If comparator ② output becomes *greater* than +6.2 Vdc, the trip status output changes from 0 Vdc to approximately 12 Vdc (logic level 1), and the trip status LED comes on. If comparator ② output becomes *less* than +6.2 Vdc, trip status output changes from 12 Vdc to approximately 0 Vdc, and the trip status LED goes off.

Trip status output/LED logic can be reversed by changing the position of the trip status output/LED logic switch. The trip status output then changes from 12 Vdc to approximately 0 Vdc (logic level 0), and LED goes off when comparator ② output becomes *greater* than +6.2 Vdc. Trip status output changes from 0 Vdc to approximately 12 Vdc, and the LED comes on when comparator ② output becomes *less* than +6.2 Vdc. Refer to Figures 16 and 17 for normal and reversed trip status output logic diagrams.

Gross Failure Output

Comparators ③ and ④ compare the 1 to 5 Vdc signal with two separate reference voltages, which can be adjusted by single-turn gross failure adjustment potentiometers. One of the reference voltages is set to indicate a high current failure; the other, a low current failure. When transmitter current is outside the preset high or low reference limits, the output from the comparators generates a latching gross failure output signal (approximately 24 Vdc) and turns on a gross failure indicating LED. The gross failure output/LED can be adjusted to indicate a gross failure for low transmitter currents between 0.5 and 4.0 mA or below, and high currents between 19.5 and 40 mA or above. Gross failure limits are illustrated in Figure 18.

TRIP OUTPUT	TRIP STATUS LED
0 Vdc	OFF
+ 24 Vdc	ON

Figure 16. Trip Status LED — Normal Logic.

TRIP OUTPUT	TRIP STATUS LED
0 Vdc	ON
+ 24 Vdc	OFF

Figure 17. Trip Status LED — Reversed Logic.

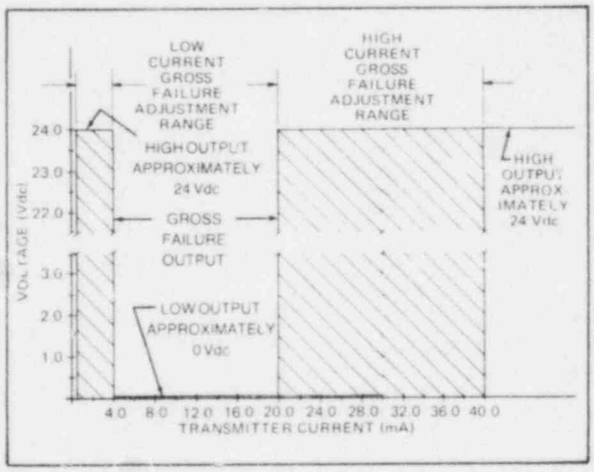


Figure 18. Gross Failure Output Limits.

Both the gross failure output signal and gross failure LED's stay lighted until manually reset by the gross failure reset button on the Master Trip Unit's front panel.

Two Analog Signals

The Master Trip Unit provides both a buffered analog signal to drive up to seven Slave Trip Units, and a buffered auxiliary analog output for external equipment. Both analog signals provide 1 to 5 Vdc outputs corresponding to 4 to 20 mA transmitter inputs or 3-wire RTD inputs.

The analog-to-Slave output has a second order break frequency at 250 Hz, while the auxiliary analog output frequency response is determined by a second order low pass filter adjustable between 0.8 and 8.0 Hz.

The auxiliary analog output is protected against the following conditions: shorting the output to ground; shorting the output to the +24 Vdc power supply; shorting the output to +125 Vdc; shorting the output to +115 Vac; and operating the output with no load.

Input/Output Capabilities

The Master Trip Unit requires a maximum of 260 mA at 24 Vdc exclusive of output loads. Both the trip output and gross failure output are capable of driving a resistive load of 24 ohms of larger, and an inductive load of up to 4 Henries. Both the trip output and gross failure output are protected by 1-1/2 amp fuses. If the trip output fuse opens, transmitter current cannot flow and a gross failure is indicated.

The input signal to the 710DU System can be monitored by using test jack J1 (red jack on front panel) which provides an unbuffered 1 to 5 Vdc signal proportional to the sensor input.

Calibration

(Detailed procedures are in the "Calibration and Operation" section.)

The Master Trip Unit can be checked or adjusted for trip point accuracy by the 710DU Calibration Unit and Readout Assembly. The Calibration Unit provides the Master Trip Unit with a 24 Vdc calibrate command signal which energizes a DPDT relay, K1 (Figure 13). At that time, transmitter current is transferred from a 250-ohm resistor to a separate 240-ohm resistor, allowing the 250-ohm resistor to receive calibration current. The calibrate command signal also causes the Master Trip Unit to produce a 24 Vdc gross failure output signal, indicating that the Trip Unit is inoperative during calibration.

When the calibration current fed to the Master Trip Unit is equal to the desired trip current (visible on the Readout Assembly), the trip point potentiometer on the Master Trip Unit's front panel is adjusted until the trip status LED *just* comes on. Calibration current can then be increased or decreased so that when it passes through the established trip point, the trip status output provides a signal to the Readout Assembly. This signal latches the upper display of the Readout Assembly at the trip point when the trip occurred. This procedure can be repeated until the trip point is set at the exact value desired.

The calibration current routed to the Master Trip Unit includes stable and transient currents, or stable current only. Stable calibration current is used to calibrate or verify trip points, and check the analog meter. Transient calibration current can be added to or subtracted from stable current to determine the time response of the Master Trip Unit, loads driven by the Trip Unit, or to set gross fail limits.

MASTER TRIP UNIT (RTD INPUT)

Refer to Figure 19 for a functional block diagram of the 710DU RTD Input Master Trip Unit.

The theory of operation for the Master Trip Unit with RTD Input is the same as the operation of the Master Trip Unit with 4-20 mA Input except for the following:

The Master Trip Unit is connected to a remote RTD via terminals 14, 15, and 4 and conditions the input signal.

The 100 ohm R_0 RTD forms part of a resistance bridge in the Master Trip Unit. The 3-wire configuration reduces the effect of RTD lead resistance changes due to temperature. The voltage differential between the active and passive legs of the bridge is amplified and becomes a buffered 1-5 Vdc bridge output signal.

This 1-5 Vdc signal is proportional to 10-50% of span. The maximum adjustable span is 568 F. The minimum adjustable span is 100 F. The zero may be suppressed from 32 F to 500 F.

The bridge circuit also compensates for the nonlinearity inherent in a Platinum RTD. The linearity adjustment is set as a function of the desired span.

The range of zero and span adjustments available is shown graphically in Figure 20. Zero, span, and linearity potentiometers are located on the circuit board and are not accessible when the board is installed in the Card File.

The buffered 1-5 Vdc bridge output signal is fed into a 250 Hz low pass filter which is identical to the filter in the 4-20 mA Input Master Trip Unit. The remaining functional blocks; trip comparator, gross fail comparators, and analog output to slave are identical to those described in the 4-20 mA Input Master Trip Unit section.

The auxiliary analog output circuit in the RTD Input Master Trip Unit does not have an adjustable 0.8 to 8.0 Hz low pass filter. Otherwise, it is the same as the 4-20 mA Master Trip Unit.

Figure 19 shows the block diagram of the RTD Input Master Trip Unit.

Calibration

(Detailed procedures are in the "Calibration and Operation" section.)

The Master Trip Unit can be adjusted or checked for trip point accuracy by the 710DU Calibration Unit and Readout Assembly. The Calibration Unit provides the Master Trip Unit with a 24 Vdc calibrate command signal which energizes a DPDT relay, K1 (Figure 19). At that time, the

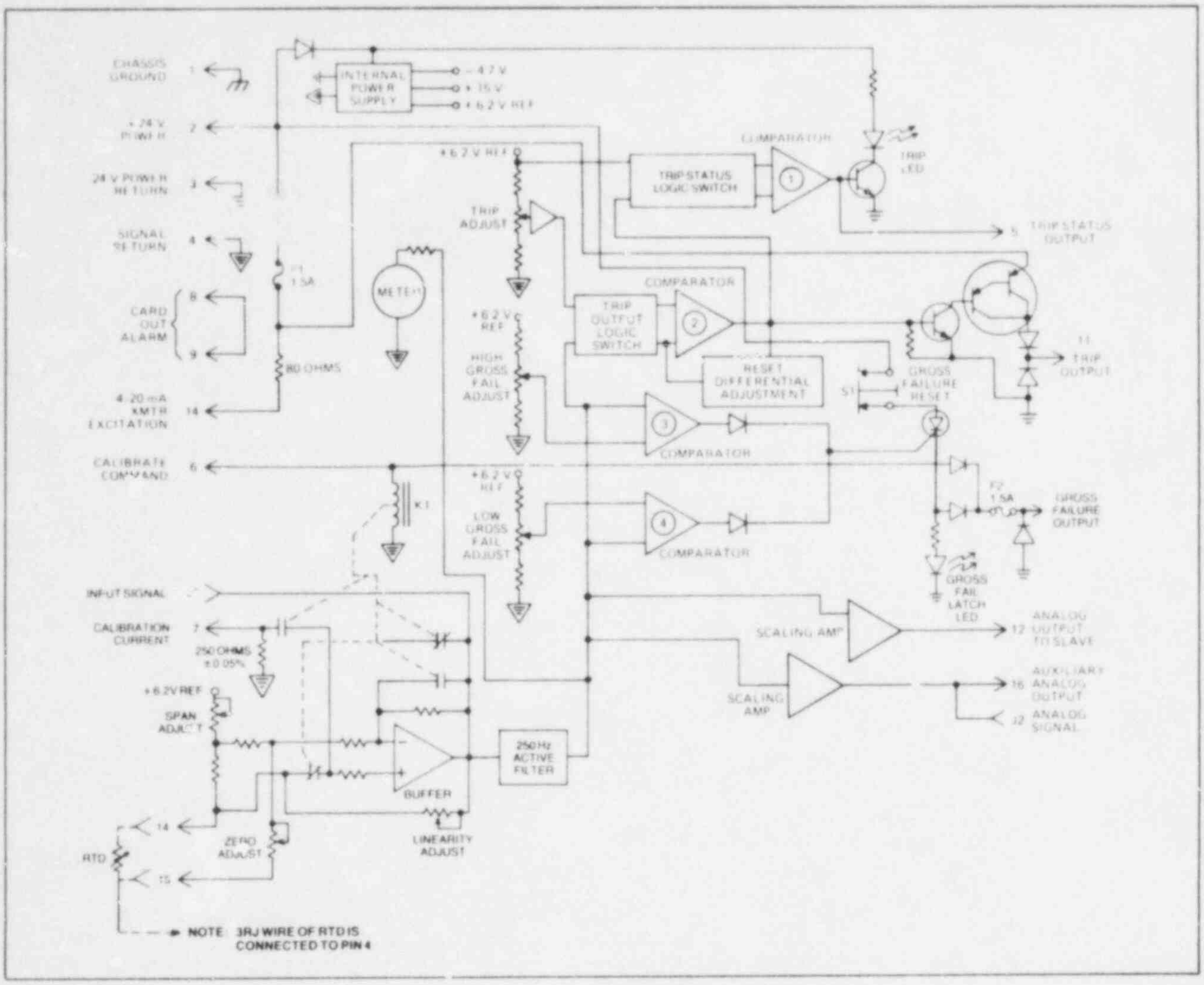


Figure 19. RTD Input Master Trip Unit Functional Block Diagram

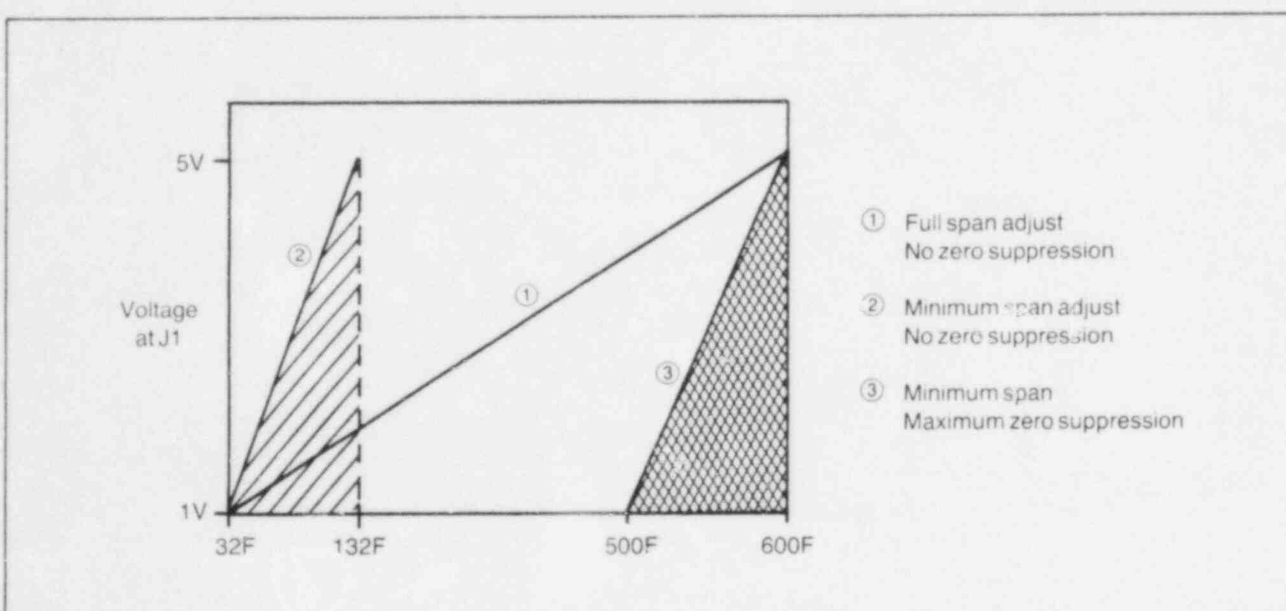


Figure 20. Adjustment Range of RTD Input

Bridge RTD leg is disconnected from the amplifier and a 250 ohm precision resistor is connected between the amplifier input and ground. The feedback resistor on the amplifier is also shorted and the amplifier becomes a unity gain buffer.

The 250 ohm resistor can now receive calibration current and 4-20 mA will genera[illegible] 5 Vdc.

The relationship between calibration current and RTD resistance is shown by the following equation:

$$\text{Equivalent Current} = 4\text{ mA} + \left(\frac{16\text{ mA}\,(R_{RTD} - R_{zero})}{(R_{full\ scale} - R_{zero})}\right)$$

Where R_{RTD} = RTD resistance at any given time

R_{zero} = RTD resistance which makes the voltage at J1 (front panel) 1.000 Vdc (zero)

$R_{full\ scale}$ = RTD resistance which makes the voltage at J1 (front panel) 5.000 Vdc (full scale)

The calibrate command signal also causes the Master Trip Unit to produce a 24 Vdc gross failure output signal, indicating that the Trip Unit is inoperative during calibration.

When the calibration current fed to the Master Trip Unit is equal to the desired trip current (visible on the Readout Assembly), the trip point potentiometer on the Master Trip Unit's front panel is adjusted until the trip status LED *just* comes on. Calibration current can then be increased or decreased so that when it passes through the established trip point, the trip status output provides a signal to the Readout Assembly. This signal latches the upper display of the Readout Assembly at the trip point when the trip occurred. This procedure can be repeated until the trip point is set at the exact value desired.

The calibration current routed to the Master Trip Unit includes stable and transient currents, or stable current only. Stable calibration current is used to calibrate or verify trip points, and check the analog meter. Transient calibration current can be added to or subtracted from stable current to determine the time response of the Master Trip Unit, loads driven by the Trip Unit, or to set gross fail limits.

SLAVE TRIP UNIT

Refer to Figure 21 for a functional block diagram of the 710DU Slave Trip Unit.

The Slave Trip Unit mounts in any of the first 12 Card File locations; it is connected to a 24 Vdc power supply via terminals 2, 3, and 4 of the Card File, and to a Master Trip Unit via terminals 12 and 4 of both Units.

A standard design internal power supply regulates the 24 Vdc input +15 Vdc, providing the positive voltage required by the operational amplifiers (used as comparators or a buffer) in the Slave Trip Unit circuit. The +15 Vdc drives an oscillator used to generate -4.7 Vdc, the negative voltage required by the operational amplifiers. In addition, the +15 Vdc generates a +6.2 Vdc reference voltage.

Each Slave Trip Unit in the 710DU System is driven by the 1 to 5 Vdc analog signal of a Master Trip Unit. The Slave Unit conditions the signal to provide both an additional, independently adjustable trip point for the same input sensor connected to the Master Unit, and an additional gross failure circuit.

The theory of operation for the trip output, trip status output, and gross failure output generated by the Slave Trip Unit circuit is identical to that of the Master Trip Unit. All Slave outputs are independent of Master outputs.

For information on trip output, trip status output, and gross failure output, refer to Master Trip Unit (4-20 mA Input) Section.

Input/Output Capabilities

The Slave Trip Unit requires a maximum of 225 mA at 24 Vdc exclusive of output loads. Both the trip output and gross failure output are capable of driving a resistive load of 24 ohms or more, and an inductive load of up to 4 Henries. Both the trip output and gross failure output are protected by 1-1/2 amp fuses.

Calibration

The Slave Trip Unit can be checked or adjusted for trip point accuracy by feeding calibration current from the Calibration Unit into the Master Trip Unit that is driving the Slave. The Calibration Unit and Readout Assembly are then used to monitor the trip status output from the Slave Trip Unit.

When calibration current is equal to the desired trip current, the trip point potentiometer is adjusted until the trip status LED *just* comes on. Calibration current then can be increased or decreased so that when it passes through the trip point, the trip status output from the Slave Trip Unit provides a signal to the Readout Assembly. The trip status signal latches the upper display of the Readout Assembly at the trip point when the trip occurred.

The preceding procedure can be repeated as required to set the trip point to the exact value desired. See the "Calibration and Operation" section for detailed procedures.

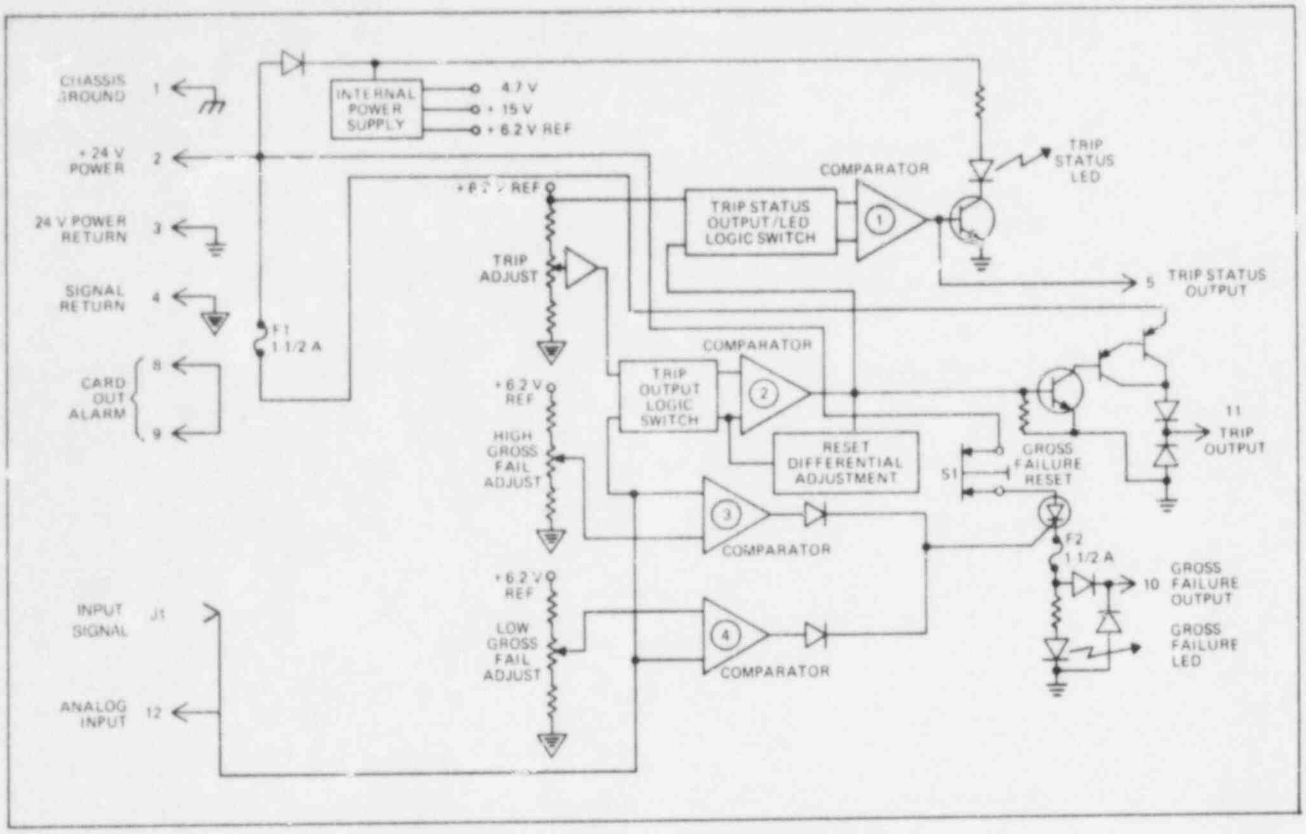


Figure 21 Slave Trip Unit Functional Block Diagram.

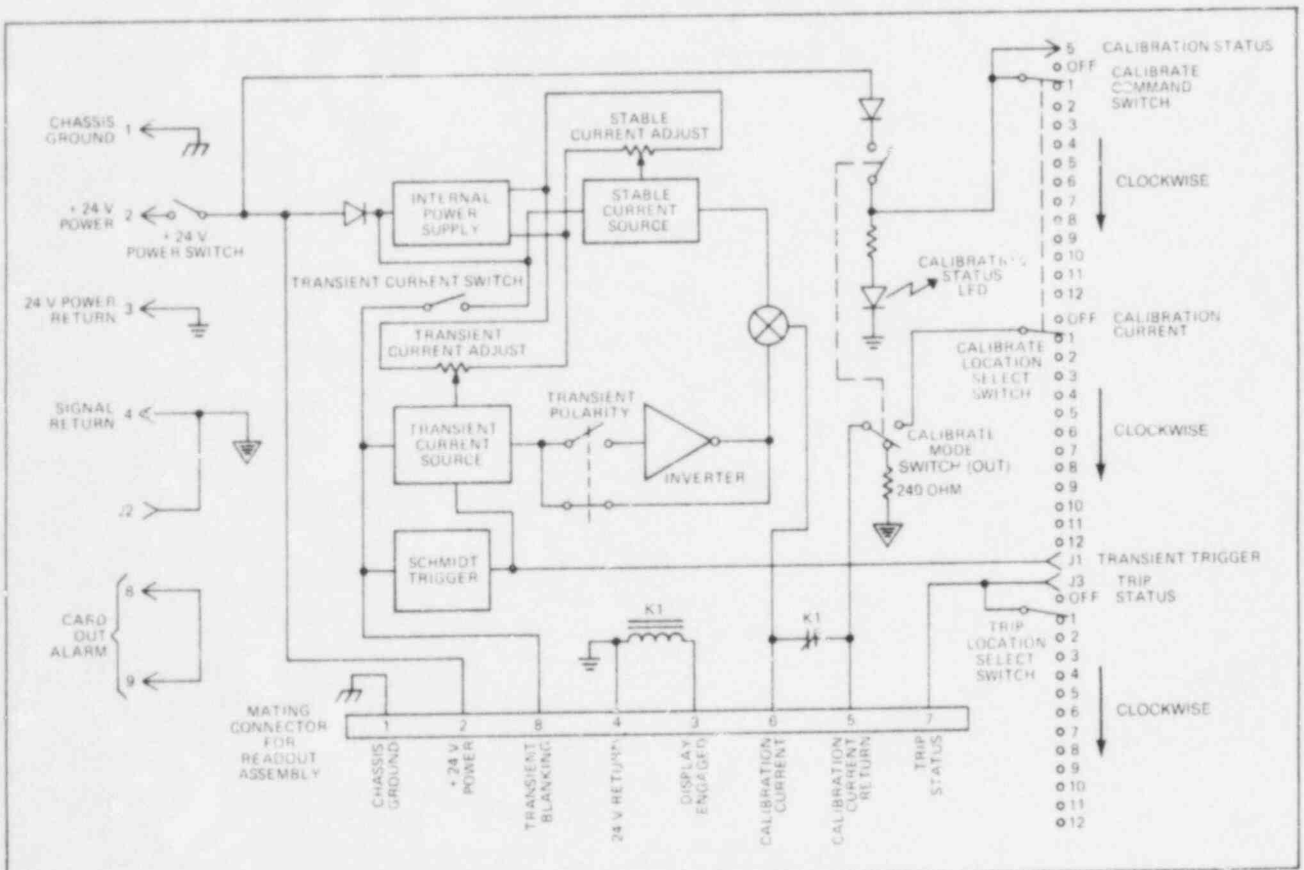


Figure 22. Calibration Unit Functional Block Diagram.

CALIBRATION UNIT

Refer to Figure 22 for a functional block diagram of the 710DU Calibration Unit.

The Calibration Unit mounts in location 13 of the Card File and is connected to any Master and Slave Trip Units in locations 1 through 1[illegible] terminals 5, 6, and 7 of the Trip Units. The 24 Vdc pow[illegible] connected to terminals 2 and 3 of the Calibration Unit is also used to power the Readout Assembly when it is inserted in the Calibration Unit.

An internal power supply regulates the 24 Vdc to generate reference voltages used in establishing stable and transient current sources. The calibration current produced by the Calibration Unit can be stable current only, or the sum or difference of stable and transient currents. Stable calibration current is adjustable from 3.5 to 20.5 mA by a 10-turn stable current amplitude potentiometer. A single-turn push/pull transient current amplitude potentiometer has two functions: it allows transient calibration current to be adjusted from 0.5 to 20.5 mA, and to be either engaged or disengaged from stable current. If transient current is engaged, a transient polarity switch determines whether it is added to or subtracted from the stable current.

Stable Current Operation

When a Readout Assembly is inserted, relay K1 in the Calibration Unit is opened and stable calibration current is routed to the Readout where it is measured with a 0.01 mA resolution. The calibration current then goes to the Master Trip Unit which is being calibrated (or, which is driving a Slave Trip Unit).

If a Readout Assembly is not plugged into the Calibration Unit, relay K1 is closed and the calibration current is either routed to a 240-ohm resistor in the Calibration Unit or — if the Calibration Unit is in the calibrate mode — to a Master Trip Unit for calibration. If calibration current is routed to the 240-ohm resistor, approximate voltage levels are established throughout the Calibration Unit even though it is not supplying current to a specific Trip Unit. When the calibrate mode is activated, calibration current is routed from the resistor to the appropriate Trip Unit.

Stable calibration current has a maximum rate of change of 1.0±0.1 mA per second.

Transient Current Operation

When the push/pull transient current potentiometer is pushed in to engage transient current, a Schmidt trigger is activated and transient current is routed the same way as stable current. Activating the transient current produces a current step with a rise or fall time not in excess of 100 microseconds.

When transient current is activated, a 24 Vdc transient blanking signal is sent to the Readout Assembly to blank out the trip current display (see Readout Assembly theory of operation).

The transient trigger signal can be monitored through test jack J1 on the Calibration Unit's front panel. J1 receives a fast rise time signal from the Schmidt trigger that activates the transient current. The signal can be used to trigger an oscilloscope for time delay measurements of the 710DU System or equipment driven by it.

Calibration Status LED and Signal

When the double-pole calibrate command/calibration current switch is activated (pushed in), the calibration status LED comes on. In addition, a 24 Vdc calibration status signal is generated for remote display to indicate which Card File has a Trip Unit being calibrated.

Calibration Select and Command Switch

The Calibration Unit has two 13-position rotary, concentric push/pull switches — a single-pole switch on the outer shaft, and a double-pole switch on the inner shaft. The switches are used to route the calibrate command signal, calibration current, and trip status signal. The double-pole switch selects the Master Trip Unit to be calibrated (or which is driving a Slave to be calibrated) and, when pushed in, routes the calibrate command and calibration current to that Unit. The single-pole switch selects the Master or Slave Trip Unit whose trip status is being monitored and routes the trip status signal from that Trip Unit to the Calibration Unit, and ultimately to the Readout Assembly.

Test Jacks

The Calibration Unit's circuit provides for the three test jacks. J1, discussed previously, is used to monitor the transient trigger signal. J2 is a signal return which can be used for both the Calibration Unit and Master Trip Units. J3 accesses the trip status output of the Master or Slave Trip Unit being calibrated.

READOUT ASSEMBLY

Refer to Figure 23 for a functional block diagram of the 710DU Readout Assembly.

The Readout Assembly plugs into the 710DU Calibration Unit, with electrical connections made through a 15-pin mating connection. The [illegible] 24 Vdc input is supplied via pins 2 and 4 of the connector. (Other pin designations are detailed in the "Wiring and Installation" section.)

An internal dc-to-dc converter generates the required +15 Vdc, −15 Vdc, and +5 Vdc required by the Readout Assembly circuit. A zener diode provides a +18 Vdc reference signal.

When inserted in the Calibration Unit, the Readout Assembly provides a 24 Vdc display engaged signal which opens a relay (K1) in the Calibration Unit, routing the calibration current through a 50-ohm resistor in the Readout Assembly. The 0.2 Vdc to 1.0 Vdc developed across the 50-ohm resistor is buffered, amplified, and fed into a voltage-to-frequency converter.

Pulses Produced

A 40.2 K Hz crystal oscillator signal is fed into a divide-by-16 counter, with the output from the counter fed into a four-bit counter. The outputs from the four-bit counter, together with logic circuitry, determine window, latch, and reset pulses.

The window pulse and the output from the voltage-to-frequency converter are used to determine the clock pulses which are fed into two counter/driver/multiplexer (CDM) chips. The clock pulses are proportional to calibration current and are counted by the CDM's. The CDM's convert the pulses to signals that drive two separate four-digit, seven-segment displays (the trip current and calibration current displays).

The reset logic pulse from the logic circuitry resets the CDM's, while the latch logic pulse determines which numbers stored in the CDM's will appear on the two displays.

Trip Status Signal

A trip status signal (either 0 Vdc or 12 Vdc) from the Master or Slave Trip Unit under calibration latches the upper (trip current) display when a trip action occurs, and causes a trip status LED to indicate that the trip current display is latched. The display remains latched and the LED on until the trip status voltage changes state, or the trip current display reset button is pushed. After the reset button is pushed, the trip current can be read for reversed trip status logic.

Transient Blanking Signal

The Readout Assembly circuit receives a transient blanking signal that blanks out the trip current display when transient current is engaged. The blanking signal prevents erroneous readings on the display which might result from the fast rise time of the transient current.

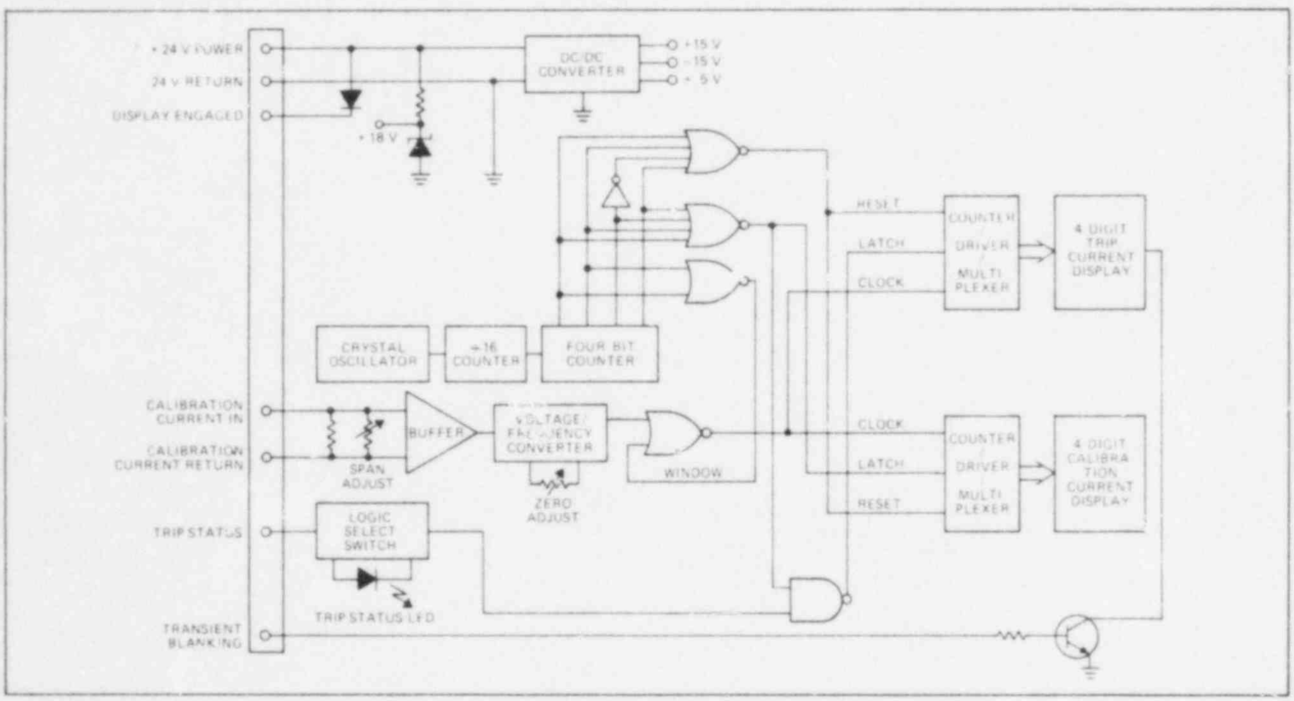


Figure 23. Readout Assembly Functional Block Diagram.

SECTION V
WIRING AND INSTALLATION

GENERAL

Wiring and installation instructions for the 710DU Trip/ Calibration System are described in this section. Complete these steps before proceeding to the "Calibration and Operation" procedures discussed in Section VI.

WIRING

Card File

The wired 710DU Card File is shown in Figure 24.

The terminal bars are numbered on the photo from right to left; TB1 through TB12 are for Master or Slave Trip Units, TB13 and TB14 for the Calibration Unit. Terminal bar TB1 shows how individual termials are designated on the first 13 bars (i.e., terminal bar number followed by terminal number). Terminal numbering for bar TB14 is shown on the photo.

Bus bars are included across terminals 1 and 2 of terminal bars TB1 through TB13. Terminal 1 is chassis ground; Terminal 2 is 24 Vdc power; Terminal 3 is the power return for all loads **except** analog-to-Slave, auxiliary analog outputs, and RTD bridge reference on RTD Masters; and Terminal 4 is the signal return for those three functions, as well as transmitter current and small currents used to generate reference voltages in each Master Trip Unit.

For 710DU calibration purposes, the Card File also provides an electrical interface between the Calibration Unit and Master or Slave Trip Units. Insulated, tin-coated copper wires connect terminals 5, 6, and 7 of terminal bars TB1 through TB12 to bars TB13 and TB14, providing for trip status, calibrate command, and calibration current. See Tables 12 and 13 for interface details.

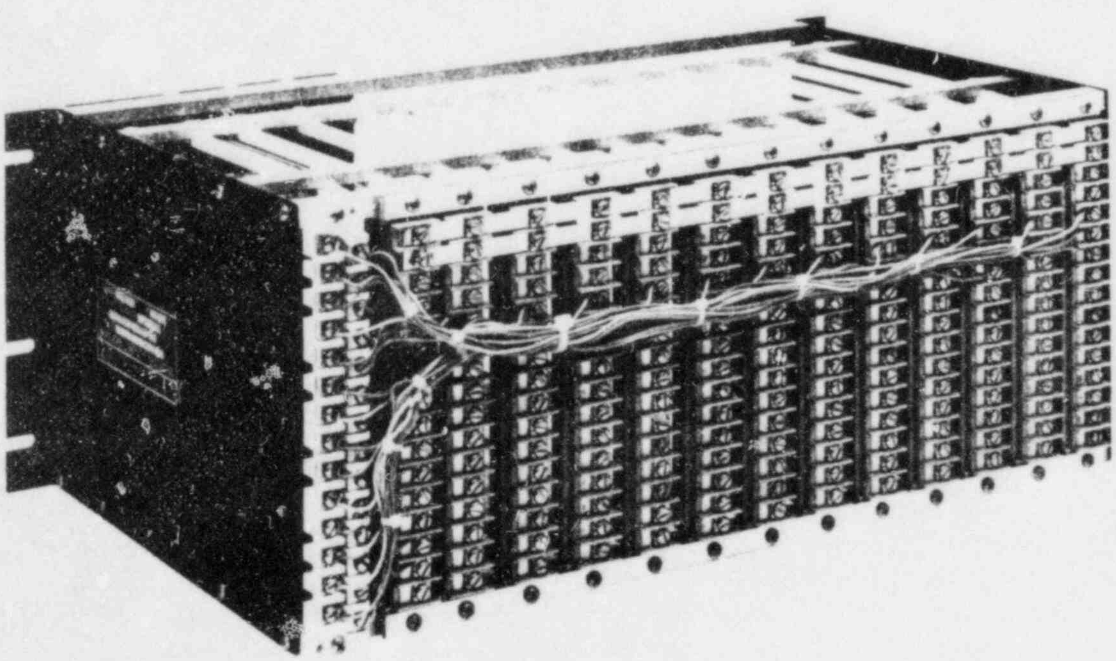


Figure 24. Wired 710DU Card File.

TABLE 12

CARD FILE TERMINAL ASSIGNMENTS
Master and Slave Trip Units
Terminal Bars TB1 through TB12

NOTE: Although calibrate command and calibration current signals are *routed* to all Trip Units, they are used only by Master Trip Units

Terminal	Signal Nomenclature	Remarks
1	Chassis Ground	Should be grounded to the relay rack external to the Card File.
2	+24 V Power	
3	24 V Power Return	This ground is the return for all loads except the analog-to-Slave and auxiliary analog outputs. Power return must be bussed back to the power supply separate from the signal return.
4	Signal Return	This ground is the return for the analog-to-Slave and auxiliary analog outputs, transmitter current, and small currents used to generate reference voltages in each Master Trip Unit. Signal return must be bussed back to the power supply separate from the power return. USE SHIELDED CABLE.
	RTD Bridge Connection	On RTD Input Master Trip Units, this ground also generates the reference voltage for the resistance bridge. The third wire of the RTD is connected to this terminal. USE SHIELDED CABLE.
5	Trip Status	0 or 12 Vdc logic level to the Readout Assembly in the Calibration Unit. It latches the trip current display after a trip action.
6	Calibrate Command (Master Trip Units)	24 Vdc signal from the Calibration Unit which opens the transmitter signal loop and closes the calibration current loop. It also causes a gross failure indication output on the Master Trip Unit.
7	Calibration Current (Master Trip Units)	Input of total calibration current from the Calibration Unit.
8 9	Card Out Alarm Card Out Alarm	Terminals 8 and 9 are shorted together on the printed circuit board for the Card Out Alarm system. See K4 in Figure 24.
10	Gross Failure Output	Drive for external relays which signals that preset high or low transmitter signal limits have been exceeded, or a Trip Unit is being calibrated.
11	Trip Output	Drive for external relays which operates when the trip point is passed through.
12	Analog-Output-to-Slave (Master Trip Units)	0 to 10 Vdc (calibrated from 1 to 5 Vdc) analog signal proportional to transmitter current or 3-wire RTD signal. Bussed back to power supply by signal return.
	Analog Input (Slave Trip Units)	0 to 10 Vdc (calibrated from 1 to 5 Vdc) analog signal from Master Trip Unit. Slave Trip Unit comparators use this signal to determine the trip output state.
13	Not Used	
14	4 to 20 mA Transmitter Excitation	17.4 to 22.7 Vdc nominal excitation to remote transmitter. USE SHIELDED CABLE.
	RTD Bridge Connection	RTD lead to resistance bridge circuit. Single lead end to terminal 14. USE SHIELDED CABLE.
15	4 to 20 mA Transmitter Return	Transmitter current input to Master Trip Unit. Current is fed through a 250-ohm resistor. USE SHIELDED CABLE.
	RTD Bridge Connection	RTD lead to resistance bridge circuit. Dual lead end to terminal 15. USE SHIELDED CABLE.
16	Auxiliary Analog Output (Master Trip Units)	0 to 10 Vdc (calibrated from 1 to 5 Vdc) analog signal proportional to transmitter current for driving external recorders, controllers, etc. Bussed back to power supply by signal return. The signal is capable of driving resistive loads from 1,500 ohms and up.

TABLE 13
CARD FILE TERMINAL ASSIGNMENTS
Calibration Unit – Terminal Bars TB13 and TB14

Terminal	Signal Nomenclature	Card File Location	Remarks
TB13-1	Chassis Ground	–	Grounded to relay rack external to Card File.
TB13-2	+24 V Power	–	
TB13-3	24 V Power Return	–	
TB13-4	Signal Return	–	
TB13-5	Calibration Status	–	24 Vdc signal for remote indication that the Calibration Unit is in use. Signal will drive a resistive load of 75 ohms and up, and an inductive load of up to 0.8 Henries.
TB13-6	Calibrate Command	12	24 Vdc signal to selected Trip Unit to enable it to accept calibration current.
TB13-7	Calibration Current	12	Sum of stable and transient calibration current to selected Trip Unit.
TB13-8	Card Out Alarm	–	Terminals 8 and 9 are shorted together on the printed circuit board for the Card Out Alarm system.
TB13-9	Card Out Alarm	–	
TB13-10	Trip Status	1	0 or 12 Vdc logic level from Trip Unit selected. Latches trip current display on Readout Assembly.
TB13-11	Calibrate Command	1	24 Vdc signal to selected Trip Unit to enable it to accept calibration current.
TB13-12	Calibration Current	1	Sum of stable and transient calibration current to selected Trip Unit.
TB13-13	Trip Status	2	0 or 12 Vdc logic level from Trip Unit selected. Latches trip current display on Readout Assembly.
TB13-14	Calibrate Command	2	24 Vdc signal to selected Trip Unit to enable it to accept calibration current.
TB13-15	Calibration Current	2	Sum of stable and transient calibration current to selected Trip Unit.
TB13-16	Not Used	–	
TB14-1	Trip Status	3	0 or 12 Vdc logic level from Trip Unit selected. Latches trip current display on Readout Assembly.
TB14-2	Calibrate Command	3	24 Vdc signal to selected Trip Unit to enable it to accept calibration current.
TB14-3	Calibration Current	3	Sum of stable and transient calibration current to selected Trip Unit.
TB14-4	Trip Status	4	0 or 12 Vdc logic level from Trip Unit selected. Latches trip current display on Readout Assembly.
TB14-5	Calibrate Command	4	24 Vdc signal to selected Trip Unit to enable it to accept calibration current.
TB14-6	Calibration Current	4	Sum of stable and transient calibration current to selected Trip Unit.
TB14-7	Trip Status	5	0 or 12 Vdc logic level from Trip Unit selected. Latches trip current display on Readout Assembly.
TB14-8	Calibrate Command	5	24 Vdc signal to selected Trip Unit to enable it to accept calibration current.
TB14-9	Calibration Current	5	Sum of stable and transient calibration current to selected Trip Unit.
TB14-10	Trip Status	6	0 or 12 Vdc logic level from Trip Unit selected. Latches trip current display on Readout Assembly.
TB14-11	Calibrate Command	6	24 Vdc signal to selected Trip Unit to enable it to accept calibration current.
TB14-12	Calibration Current	6	Sum of stable and transient calibration current to selected Trip Unit.
TB14-13	Trip Status	7	0 or 12 Vdc logic level from Trip Unit selected. Latches trip current display on Readout Assembly.
TB14-14	Calibrate Command	7	24 Vdc signal to selected Trip Unit to enable it to accept calibration current.
TB14-15	Calibration Current	7	Sum of stable and transient calibration current to selected Trip Unit.
TB14-16	Trip Status	8	0 or 12 Vdc logic level from Trip Unit selected. Latches trip current display on Readout Assembly.
TB14-17	Calibrate Command	8	24 Vdc signal to selected Trip Unit to enable it to accept calibration current.
TB14-18	Calibration Current	8	Sum of stable and transient calibration current to selected Trip Unit.
TB14-19	Trip Status	9	0 or 12 Vdc logic level from Trip Unit selected. Latches trip current display on Readout Assembly.
TB14-20	Calibrate Command	9	24 Vdc signal to selected Trip Unit to enable it to accept calibration current.
TB14-21	Calibration Current	9	Sum of stable and transient calibration current to selected Trip Unit.
TB14-22	Trip Status	10	0 or 12 Vdc logic level from Trip Unit selected. Latches trip current display on Readout Assembly.
TB14-23	Calibrate Command	10	24 Vdc signal to selected Trip Unit to enable it to accept calibration current.
TB14-24	Calibration Current	10	Sum of stable and transient calibration current to selected Trip Unit.
TB14-25	Trip Status	11	0 or 12 Vdc logic level from Trip Unit selected. Latches trip current display on Readout Assembly.
TB14-26	Calibrate Command	11	24 Vdc signal to selected Trip Unit to enable it to accept calibration current.
TB14-27	Calibration Current	11	Sum of stable and transient calibration current to selected Trip Unit.
TB14-28	Trip Status	12	0 or 12 Vdc logic level from Trip Unit selected. Latches trip current display on Readout Assembly.

Customer Wiring

Interconnections between Master Trip Units and Slave Trip Units must be made by the customer at terminal 12 of the Trip Units involved. In addition, for proper operation it is important that terminal 4 of each Trip Unit be connected as shown in Figure 25.

The customer also is responsible for installing all wiring to transmitters, relays, power supplies, meters, recorders, alarms, or any other instrumentation used with the 710DU System. Shielded cables must be used when connecting transmitters to the Card File, with the shield connected to the chassis (terminal 1 of each terminal bar) at the Card File. Shielded cables also should be used for auxiliary analog outputs.

The Card File wiring connections may be bare stripped wire, or crimp on spade, or ring tongue terminals.

For further information on wiring, refer to the applicable Rosemount Specification Control Drawing. Figures 25, 26, and 27 show sample interconnections.

Figure 25 illustrates an application of the 710DU System where pressure transmitters are powered from the same power supply as the Master Trip Units. Four-wire transmitters can be used if the transmitter signal is fed to the Master Trip Unit on terminals 15 and 4. The diagram also shows how to interconnect Master Trip Units and Slave Trip Units to obtain multiple trip points from a single transmitter input.

The system shown in Figure 26 includes a transmitter, power supplies, relays, and a 710DU Master Trip Unit.

A retrofit of an existing power plant with the 710DU Trip/Calibration System is illustrated in Figure 27. The diagram shows what must be done to install the 710DU System and accompanying instrumentation in place of an existing pressure switch. The cabinet (relay rack) housing the 710DU System, power supplies, and relays should be located in the vicinity of the transmitter(s) so that the resistance of the wire used to make connections between the 710DU System and transmitters does not exceed 16 ohms.

Readout Assembly Interface

A blind mated DA-15 connector pair provides the electrical interface between the Calibration Unit and Readout Assembly. The pins are numbered on the Readout Assembly connector as shown in Table 14.

TABLE 14

MATING CONNECTOR PIN DESIGNATIONS
Readout Assembly

Pin Number	Designation
1	Chassis ground
2	+24 Vdc power
3	Display engaged
4	+24 Vdc power return
5	Calibration current return
6	Calibration current
7	Trip status output
8	Transient blanking
9	No connection
10	No connection
11	No connection
12	No connection
12	No connection
13	No connection
14	No connection
15	No connection

INSTALLATION

Card File

The Card File mounts in a standard 19-inch relay rack, along with the power supplies and relays used with the 710DU Trip/Calibration System. The relay rack, power supplies, and relays are selected and supplied by the customer.

The Card File has center mounting screw slots which are not required for support of the Card File in the relay rack, but which can be used to mount an optional tamper-proof bar over the Master and Slave Trip Units. The bar guards against inadvertent alteration of trip point adjustments and, if used, must be supplied by the customer.

Master and Slave Trip Units

Master and Slave Trip Units are installed in the first 12 Card File locations (left to right as viewed from the front of the Card File). Each Trip Unit slides into the Card File along an upper and a lower nylon card guide, and plugs into a single-sided edge card connector at the rear of the Card File. The Trip Unit is held in place by two captive screws which engage the upper and lower rails of the Card File.

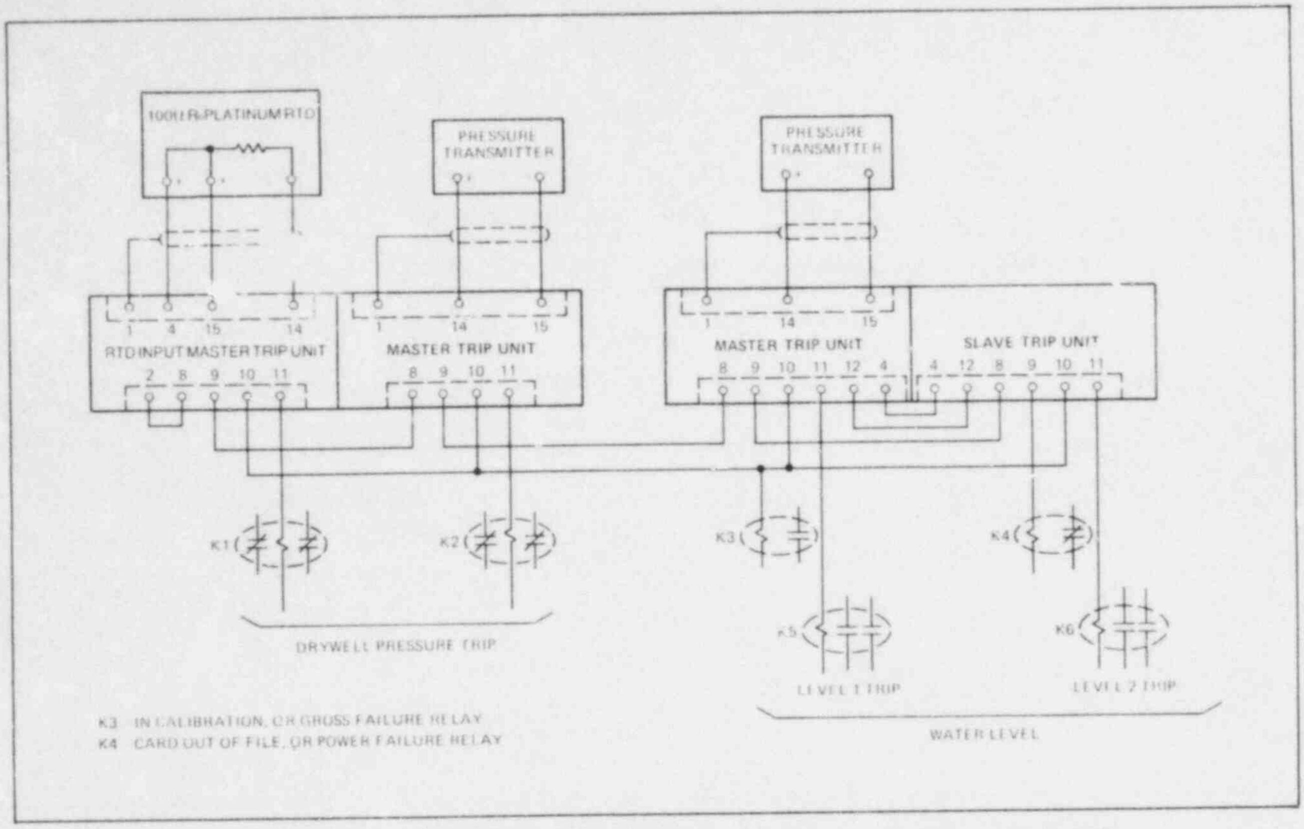


Figure 25. Sample Application of 710DU System with Pressure Transmitters and an RTD.

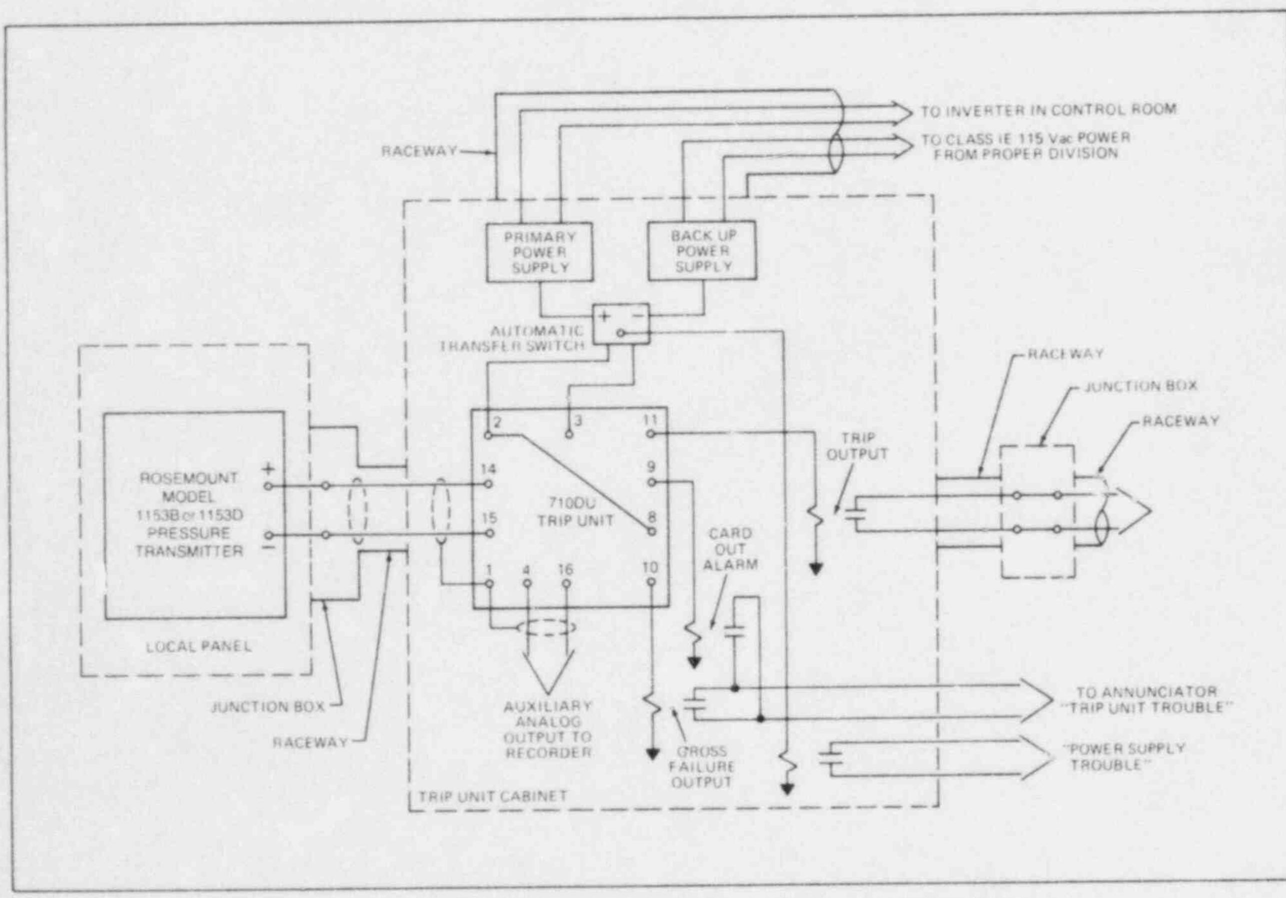


Figure 26. Sample Transmitter and Master Trip Unit Interconnection Diagram.

Calibration Unit

Only the Calibration Unit can be installed in Card File location 13 (far right) because of the different alignment of the card guide and connectors. The Calibration Unit slides into the Card File along two upper and two lower nylon card guides, and plugs into two edge card connectors — one single-sided and the other double-sided — at the rear of the Card File. Two front panel captive screws hold the Calibration Unit in place in the Card File.

Readout Assembly

The Readout Assembly slides into the Calibration Unit through a spring-loaded door, with electrical connection made through the blind mated DA-15 connector pair discussed previously. Since the Readout Assembly is portable, it can be transferred easily to any other Calibration Unit in the 710DU Trip/Calibration System.

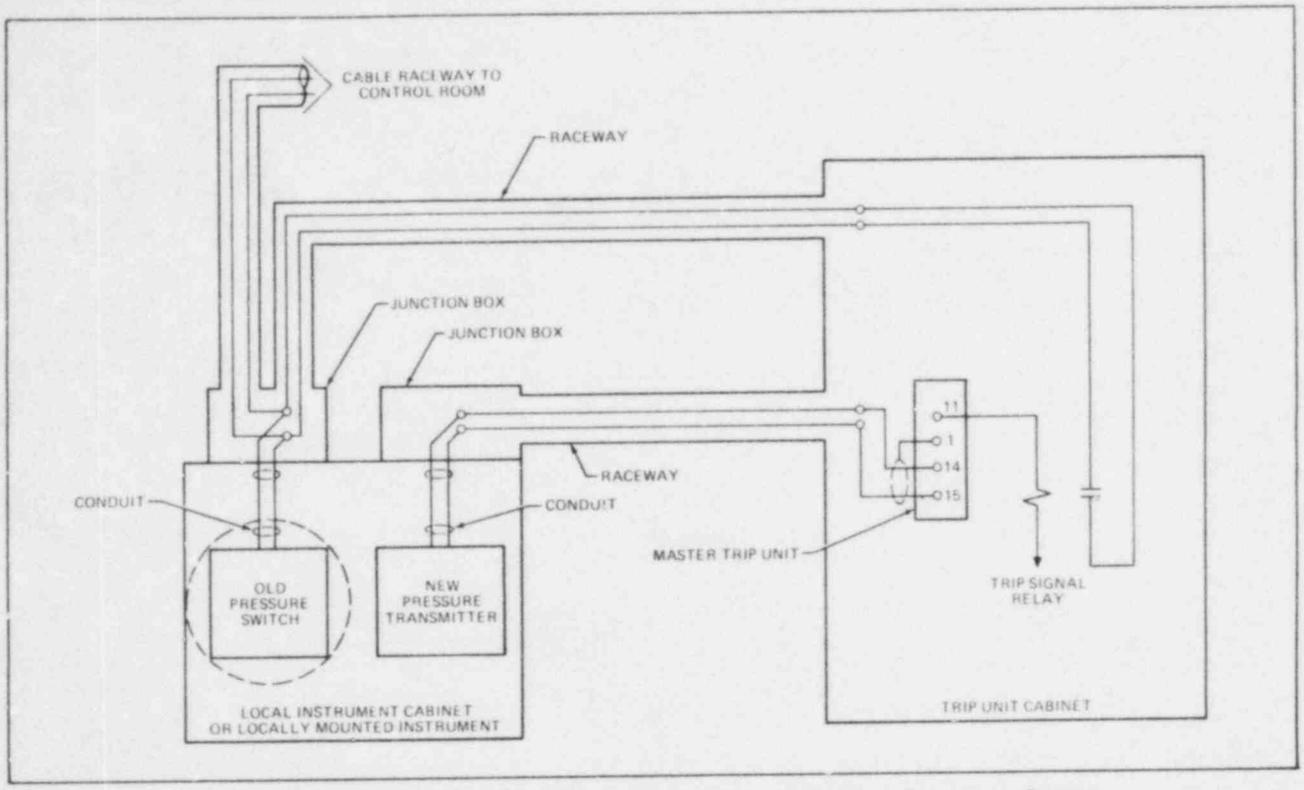


Figure 27. Retrofit of an Existing Power Plant with the 710DU Trip/Calibration System.

SECTION VI
CALIBRATION AND OPERATION

GENERAL

The wiring and installation steps presented in Section V must be completed before performing the procedures discussed in this section.

Calibration need not be performed immediately after wiring and installation, but must be accomplished before the 710DU Trip/Calibration System is put into operation. The frequency of calibration after the 710DU System is operative is determined by customer requirements and specifications.

CALIBRATION

Installation and checkout procedures below must be performed before the 710DU Trip/Calibration system is calibrated. Some can be completed in an assembly area where the elements of a 710DU System are unpacked, assembled, and briefly checked for proper operation. Other procedures should be performed after the 710DU System is moved to its final operating area.

Assembly Area

1. Install the Card File, power supplies, and relays in the relay rack (cabinet).

2. Insert the Master and Slave Trip Units and Calibration Unit into the Card File, making electrical connections with the edge card connectors at the rear of the Card File. Tighten the two captive screws on the front panel of each Unit.

3. Complete the electrical interface between Master Trip Units and Slave Trip Units by connecting terminals 12 and 4 of the Master(s) to terminals 12 and 4 of the appropriate Slave(s), respectively.

4. Wire the power supply and relays to the Card File (see Tables 12 and 13, Section V).

5. Conduct the following brief functional test to ensure that the power supply and Trip Units are properly connected, trip and gross failure actions are occurring, and nothing was damaged in shipment.

   a. Make sure the Calibration Unit power switch is OFF.

   b. Apply 24 Vdc power to the Card File. All gross failure lights on the Trip Units should be lighted since the Card File is not connected to any input sensors.

   c. Turn the stable current amplitude adjustment to its maximum position (full clockwise).

   d. Make sure the transient current amplitude adjustment is disengaged (pulled out).

   e. Turn the Calibration Unit power switch ON.

   f. Using the two-part calibration select and command switch on the front of the Calibration Unit, select a Master Trip Unit and apply stable calibration current to that Trip Unit by pushing in the center knob of the switch. If the trip status LED on the Master Trip Unit was off, it should turn on; if it was on, it should go off. The analog meter should be close to full scale.

   g. Repeat this checkout procedure for all Master Trip Units, including those driving Slave Trip Units. Check the trip status LED's to see if they are off or on, as applicable.

Final Operating Area

1. Locate the cabinet containing the 710DU System, power supplies, and relays in the final operating area.

2. Connect the input sensors to the appropriate Master Trip Units in the Card File (see Table 12, Section V).

3. Connect the appropriate loads to the relays.

   NOTE: Control functions which might be initiated during calibration should not be connected until after Trip Unit Calibration.

4. Connect the 24 Vdc power supply to the appropriate ac power.

5. Apply 24 Vdc power and proceed to calibrate trip points of Master and Slave Trip Units.

Calibration of Master Trip Units (4-20 mA Input)

1. Each Master Trip Unit to be calibrated must be removed from the Card File and the following adjustments verified or set (see Figure 8, Section III).

   a. Trip output logic

   b. Trip status output/LED logic

   c. Reset differential

   d. High current gross failure trip point

   e. Low current gross failure trip point

   f. Frequency response of auxiliary analog output.

2. Reinsert the 4-20 mA Master Trip Unit in the Card File after adjustments (a) through (f) above have been made or checked.

3. Verify that 24 Vdc power is applied.

4. Install the Readout Assembly in the Calibration Unit.

5. Make sure both the two-part calibration select and command switch and the transient current amplitude adjustment are disengaged (center knob of switch and transient adjustment pulled out).

6. Turn the Calibration Unit power switch ON. The switch controls power to both the Calibration Unit and Readout Assembly.

7. Allow the Readout Assembly approximately 10 minutes warm-up time.

8. Using the calibration select and command switch, select the Card File location of the Master Trip Unit to be calibrated (both the outer and center knobs should be pointing at the same number).

9. Push in the center knob of the two-part switch to activate the Calibration Unit.

10. The gross failure output on the Master Trip Unit should provide a 24 Vdc output and the calibration status LED on the Calibration Unit should light, indicating that calibration is occurring.

    NOTE: Complete steps 11 through 18 and 27 or 19 through 27 according to the logic selected.

LED Action for:

Normal Trip Output Logic and
Normal Trip Status Output Logic
or
Reversed Trip Output Logic and
Reversed Trip Status Output Logic

11. Using the stable current amplitude adjustment, set the lower display of the Readout Assembly to the desired trip point at either the high side or low side of the reset differential (shown in Figure 8).

12. If the trip point is to be set at the *high* side of the reset differential, the Master Trip Unit trip status LED initially should be *off*. If it is on, turn the trip point adjustment potentiometer clockwise until the LED goes off. Then turn the potentiometer counterclockwise until the LED *just* comes on.

13. If the trip point is to be set at the *low* side of the reset differential, the Master Trip Unit trip status LED initially should be *on*. If it is off, turn the trip point adjustment potentiometer counterclockwise until the LED comes on. Then turn the potentiometer clockwise until the LED *just* goes off.

14. Run the stable calibration current through the trip point to verify the reset differential. Observe at what value the upper display on the Readout Assembly latches (trip status LED on Readout Assembly is lighted for latched condition). The trip current display reset button on the Readout Assembly must be reset if the trip point is to be checked for calibration current changing in the opposite direction; i.e., increasing current vs. decreasing current, or decreasing current vs. increasing current.

15. If it is necessary to readjust the reset differential, repeat steps 11 through 14.

16. If the reset differential has not been readjusted, check the trip point (either the high side or low side of the reset differential as required by application) to verify that it is the correct value.

17. If the trip point needs adjusting, repeat steps 11 and 12 or 11 and 13, as appropriate.

18. If the trip point is correct, the Master Trip Unit is ready for operation.

LED Action for:

Reversed Trip Output Logic and
Normal Trip Status Output Logic
or
Normal Trip Output Logic and
Reversed Trip Status Output Logic

19. Using the stable current amplitude adjustment, set the lower display of the Readout Assembly to the desired trip point at either the high side or low side of the reset differential (see Figure 28).

20. If the trip point is to be set at the *high* side of the reset differential, the Master Trip Unit trip status LED

initially should be *on*. If it is off, turn the trip point adjustment potentiometer clockwise until the LED comes on. Then turn the potentiometer counter-clockwise until the LED *just* goes off.

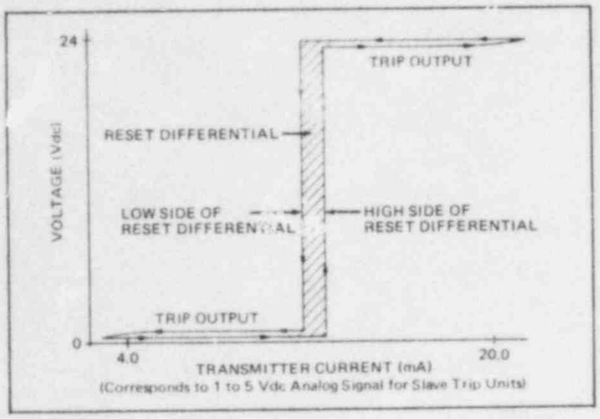


Figure 28. High Side and Low Side of Reset Differential.

21. If the trip point is to be set at the *low* side of the reset differential, the Master Trip Unit trip status LED initially should be *off*. If it is on, turn the trip point adjustment potentiometer counterclockwise until the LED goes off. Then turn the potentiometer clockwise until the LED *just* comes on.

22. Run the stable calibration current through the trip point to verify the reset differential. Observe at what value the upper display on the Readout Assembly latches (trip status LED on Readout Assembly is lighted for latched condition). The trip current display reset button on the Readout Assembly must be reset if the trip point is to be checked for calibration current changing in the opposite direction; i.e., increasing current vs. decreasing current, or decreasing current vs. increasing current.

23. If it is necessary to readjust the reset differential, repeat steps 19 through 22.

24. If the reset differential has not been readjusted, check the trip point (either the high side or low side of the reset differential as required by application) to verify that it is the correct value.

25. If the trip point needs adjusting, repeat steps 19 and 20 or 19 and 21, as appropriate.

26. If the trip point is correct, the Master Trip Unit is ready for operation.

27. After all Trip Units have been calibrated, disengage calibration by pulling out the center knob of the calibration select and command switch, and turning both knobs of the switch to OFF. Turn power switch to OFF.

Calibration of Master Trip Units (RTD Input)

1. Each Master Trip Unit to be calibrated must be removed from the Card File and the following adjustments verified or set (see Figure 9, Section III).

   a. Trip output logic

   b. Trip status output/LED logic

   c. Reset differential

   d. High current gross failure trip point

   e. Low current gross failure trip point

   f. Linearity adjustment (set for desired span).

2. Install the RTD Input Trip Unit on the Card Extender, and insert the Card Extender into the Card File.

   Set the "zero" and "span" potentiometers as follows:

   a. Connect a 999.99 ohm decade box to terminal pins 14, 15, & 4 as shown in Figure 29.

   Note: All lead wires should be the same gauge and length to reduce errors.

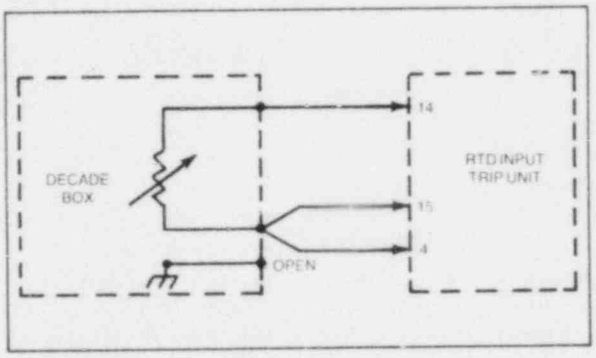


Figure 29. Decade Box Connection.

   b. Install a voltmeter in J1 on the front panel of the RTD Input Trip Unit, referencing the voltmeter to J2 on the Calibration Unit. Verify that 24 Vdc is applied. Verify linearity adjustment.

   c. Set the decade box resistance to the desired zero point of the input temperature range.

   d. Adjust the "zero" potentiometer (R86) so that the voltage at J1 reads 1.000 ± .001 Vdc.

   e. Set the decade box resistance to the desired full scale point of the input temperature range.

   f. Adjust the "span" potentiometer (R81) so that the voltage at J1 reads 5.000 ± .001 Vdc.

g. Repeat steps c-f until both "zero" and "span" settings can be achieved without adjusting R86 or R81.

h. Check the linearity of the output at ¼, ½, and ¾ of span. Readjust the linearity and repeat steps c-f until linearity values are acceptable.

i. Reinstall RTD Input Trip Unit in the Card File.

Continue with steps 3 through 27 of the Calibration of Master Trip Units (4-20 mA Input) Section.

Calibration of Slave Trip Units

1. Complete steps 1 through 7 of the calibration procedure for Master Trip Units. Note that there will be no frequency response adjustment of the auxiliary analog output (part f of step 1).

2. Turn the outer knob of the two-part calibration select and command switch to the Card File location number of the Slave Trip Unit whose trip point is to be verified or calibrated. Turn the center knob of the switch to the location number of the Master Trip Unit driving the Slave Trip Unit.

3. Repeat steps 9 through 27 of the Master Trip Unit calibration procedure. Note that the LED logic for trip output logic and trip status output logic is the same for Master and Slave Trip Units.

Calibration of Readout Assembly

To calibrate the 710DU Readout Assembly, the following equipment is required:

1. **Bench Test Facility,** designed by Rosemount Inc., for 710DU System calibration and testing. Refer to Bench Test Facility Manual 4471-3.

2. **Digital Voltmeter (DVM),** including leads to mate with the 100-ohm resistor test jacks on the front of the Bench Test Facility. Since the DVM is used for a precise measurement of the current displayed on the Readout Assembly, calibration accuracy of the 710DU System is dependent on DVM accuracy. The DVM input impedance should not be less than 10 megohms.

Steps 1 through 10 of the calibration procedures are preliminary adjustments and provide for an *approximate* calibration of the Readout Assembly. Precise calibration procedures over the 4.00 to 20.00 mA range are included in steps 11 through 16. It is important to calibrate the Readout Assembly with end points at 4.00 and 20.00 mA to minimize trip point errors over the 4.00 to 20.00 mA calibration range.

NOTE: Unless otherwise indicated, all switches or displays called out in these procedures are located on the front of the Bench Test Facility.

PRELIMINARY ADJUSTMENTS

1. Install the Readout Assembly in the Bench Test Facility slot labeled ACTIVE.

2. Apply power by pushing the POWER switch. Check the DISPLAY ENGAGED LED to determine if the Readout Assembly is properly connected (LED should be lighted).

3. Set VOLTAGE switch to 24.0 Vdc.

4. Set TRANSIENT BLANKING and TRIP STATUS switches to the OFF position. If required, press the trip current display reset on the Readout Assembly so the trip status LED is off.

5. Set the 100Ω SHUNT switch to the IN position.

6. Connect the DVM across the 100-ohm shunt resistor to measure the current supplied to the Readout Assembly.

7. Set the CURRENT RANGE SELECTOR mADC switch at the 0-10 mA range, and adjust the CAL CURRENT FINE ADJUST knob until the DVM reads 1.00 mV.

8. Turn the zero adjust potentiometer on the Readout Assembly (see Figure 11, Section III) until either display reads 0.01 mA.

9. Set the CURRENT RANGE SELECTOR mADC switch at the 18-28 mA range, and adjust the CAL CURRENT FINE ADJUST knob until the DVM reads 2.000 Vdc.

10. Turn the span adjust potentiometer on the Readout Assembly (see Figure 11, Section III) until either display reads 20.00 mA.

PRECISE ADJUSTMENTS

11. Set the CURRENT RANGE SELECTOR mADC switch at the 0-10 mA range, and adjust the CAL CURRENT FINE ADJUST knob until the DVM reads 0.400 Vdc.

12. Turn the zero adjust potentiometer (Figure 11, Section III) until the Readout Assembly reads 4.00 mA.

13. Set the CURRENT RANGE SELECTOR mADC switch at the 18-28 mA range, and adjust the CAL CURRENT FINE ADJUST knob until the DVM reads 2.000 Vdc.

14. Turn the span adjust potentiometer (Figure 11, Section III) until the Readout Assembly reads 20.00 mA.

15. Because the zero adjustment has a small interaction with the span adjustment, it may be necessary to repeat steps 11 through 14 until the Readout Assembly *exactly* indicates 4.00 mA and 20.00 mA when the DVM indicates 0.400 Vdc and 2.000 Vdc, respectively.

16. The Readout Assembly is now properly calibrated to minimize errors over the 4.00 to 20.00 mA range. Additional points over a 0 to 46 mA range may be checked by the customer as desired. By changing the VOLTAGE switch on the Bench Test Facility, the accuracy of the Readout Assembly can be verified for operation at 23.5 Vdc and 26.5 Vdc.

TRANSIENT BLANKING AND TRIP STATUS

In addition to calibration, the Bench Test Facility can be used to check the transient blanking and trip status functions of the Readout Assembly.

1. When the TRANSIENT BLANKING switch on the Bench Test Facility is turned ON, the upper display of the Readout Assembly should be blanked out.

2. With the trip status LED on the Readout Assembly off, turn the TRIP STATUS switch on the Bench Test Facility to ON to verify that the LED is operational (should light). At the same time, the current supplied to the Readout Assembly can be changed to verify that the upper display is latched.

More details on bench testing can be found in Bench Test Facility Manual 4471-3.

OPERATION

After the 710DU Trip/Calibration System has been properly calibrated, connect the loads which were not connected prior to calibration. The 710DU System then is ready for operation. Operational procedures may vary, depending on the application.

No scheduled maintenance is required for the 710DU System.

SECTION VII
ACCESSORY HARDWARE

GENERAL

The 710DU Trip/Calibration System may use any or all of the accessory hardware described in this section. While not required for system operation, the optional equipment serves the functions discussed below.

BLANK PANELS

Blank panels are available to cover unused Card File locations for Master and Slave Trip Units (1 through 12), and the Calibration Unit (13). The panels are required to maintain seismic qualification, keep foreign material from getting into unused Card File locations, and protect adjacent Trip Units.

710DU CARD EXTENDERS

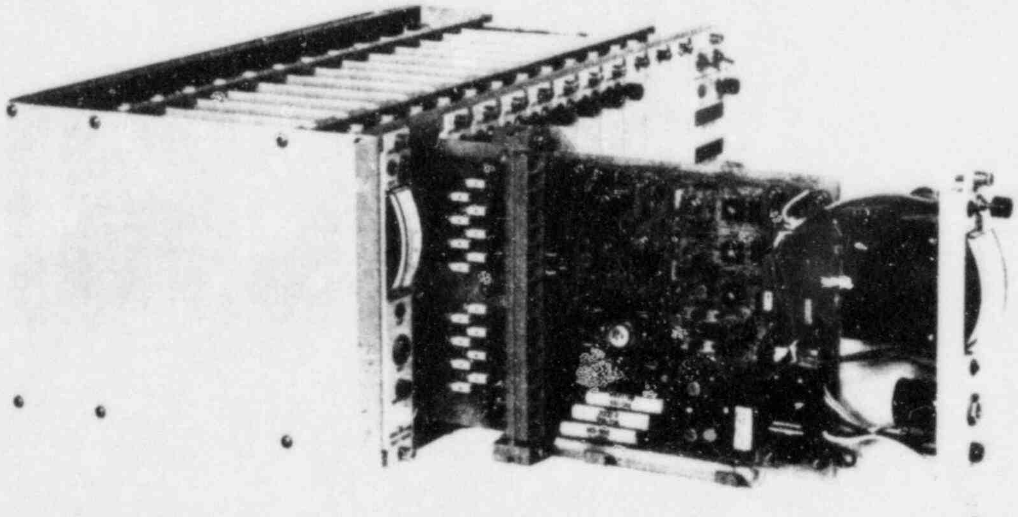
Card Extenders are available for Master and Slave Trip Units, the Calibration Unit, and Readout Assembly. Table 15 lists the dimensions of the Card Extenders.

Trip Unit and Calibration Unit Card Extenders

The Trip Unit and Calibration Unit Card Extenders are circuit card assemblies used for testing and troubleshooting Master or Slave Trip Units and the Calibration Unit. The Card Extenders bring electrical connections of these Units to the front of the Card File as shown in Figures 30 and 31.

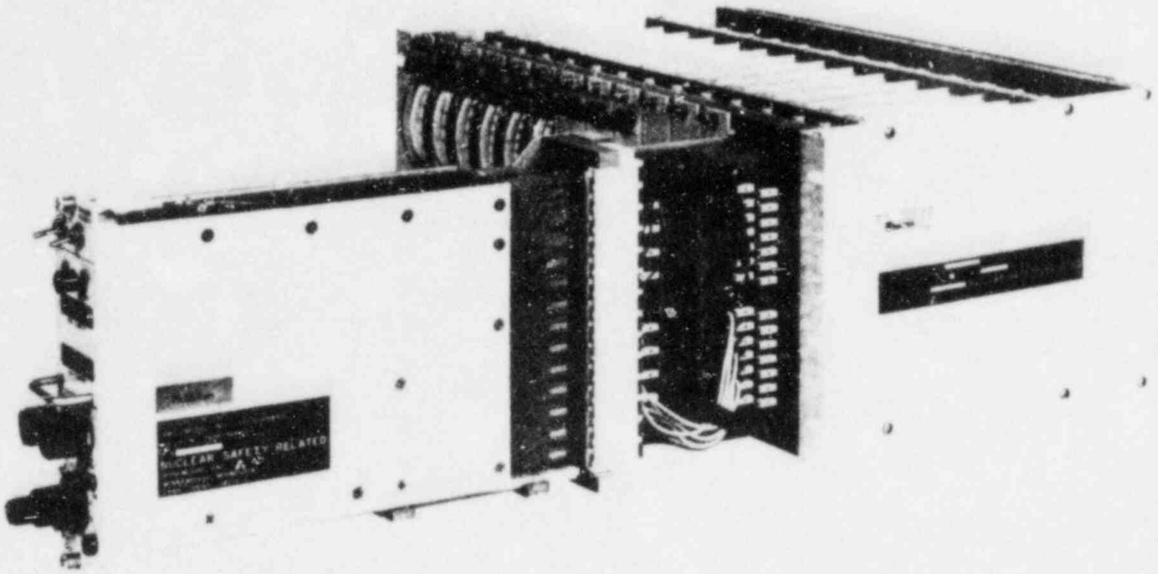
TABLE 15
CARD EXTENDER DIMENSIONS

Card Extender	Height		Width		Depth	
	Inches	Centimeters	Inches	Centimeters	Inches	Centimeters
Trip Unit	6-31/32	17.70	31/32	2.46	17-3/32	43.42
Calibration Unit	6-31/32	17.70	2-3/8	6.03	18-27/32	47.86
Readout Assembly	2-23/32	6.91	2-5/32	5.48	14-1/2	36.83



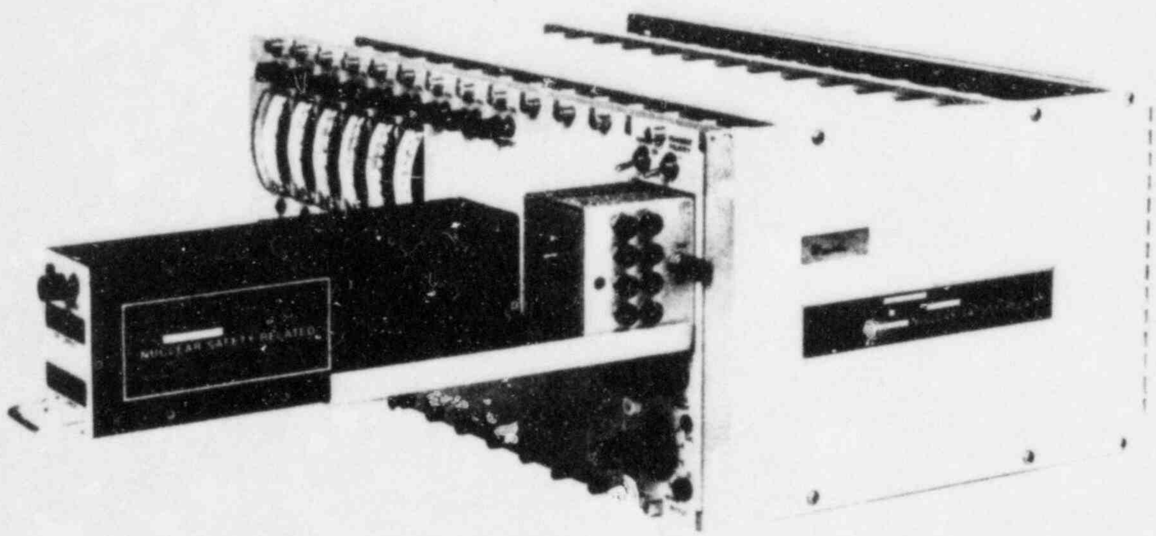
Note: This is a substitute photograph. The Model 710DU is painted black.

Figure 30. Application of 710DU Trip Unit Card Extender.



Note: This is a substitute photograph. The Model 710DU is painted black.

Figure 31. Application of 710DU Calibration Unit Card Extender.



Note: This is a substitute photograph. The Model 710DU is painted black.

Figure 32. Application of 710DU Readout Assembly Card Extender.

Both types of Card Extenders slide into the Card File, plug into the rear edge card connectors, and interface with Trip Units or Calibration Units, as applicable, through a mating connector.

In addition to providing test jacks for troubleshooting, the Trip Unit Card Extender makes the following adjustments easily accessible on Master or Slave Trip Unit circuit card assemblies.

1. Reset differential
2. High gross failure trip current
3. Low gross failure trip current
4. Trip output logic
5. Trip status output/LED logic
6. Frequency response of auxiliary analog output (Master Trip Units, 4-20 mA Input).
7. Linearity adjustment (RTD Input Master Trip Units).
8. "Zero" adjustment (RTD Input Master Trip Units).
9. "Span" adjustment (RTD Input Master Trip Units).

The Calibration Unit Card Extender brings the terminals of TB13 and TB14 (see Table 13 Section V) to the front of the Calibration Unit. Test jacks on the Card Extender are used for troubleshooting or external test equipment.

Readout Assembly Card Extender

The Readout Assembly Card Extender plugs into the Calibration Unit, making electrical connections for the Readout Assembly accessible from the front of the Card File.

Like the other Card Extenders, the Readout Assembly Card Extender has test jacks and is used for troubleshooting or connecting external test equipment. Figure 32 illustrates its use.

SECTION VIII
GLOSSARY

The Glossary defines terms associated with the 710DU Trip/Calibration System and not found in common usage. Those terms in italics in the descriptions are defined elsewhere in the Glossary.

Analog Output to Slave — A continuous voltage signal corresponding to an input sensor signal. It is generated by *Master Trip Units* and used to drive *Slave Trip Units*.

Auxiliary Analog Output — A continuous voltage signal corresponding to an input sensor signal. It is generated by *Master Trip Units*, has an adjustable frequency response, and is used to drive external recording or monitoring equipment.

Calibrate Command — A voltage signal generated by the Calibration Unit. It activates a relay in *Master Trip Units* to replace transmitter current with *calibration current*.

Calibration Current — A precisely measured current supplied by the Calibration Unit to a *Master Trip Unit* for verifying or calibrating the *trip point*. It can be *stable calibration current* only, or stable current that has *transient calibration current* added to or subtracted from it.

Calibrate Mode — A state of operation when a *trip unit* receives *calibration current* from the Calibration Unit for verification or calibration of the *trip point*.

Gross Failure — An input sensor signal failure detected by a *Master Trip Unit* when the input sensor signal is outside of preset high or low limits. Through the *analog output to Slave* signal, the *Slave Trip Unit* also can indicate a gross failure.

Gross Failure Output — A voltage signal provided by a *trip unit* whenever a *gross failure* occurs.

High Side of Reset Differential — The *trip point* for an increasing input sensor signal.

Logic Level 0 — A stable output which corresponds to approximately 0 Vdc.

Logic Level 1 — A stable output which corresponds to approximately 24 Vdc. (The exception to this is the *trip status output* which corresponds to approximately 12 Vdc).

Low Side of Reset Differential — The *trip point* for a decreasing input sensor signal.

Master Trip Unit — A *trip unit* which receives an input signal from a remote sensor. It provides a *trip output*, a *gross failure output*, and two analog signals.

Normal Trip Output Logic — It provides a high (24 Vdc) *trip output* when the transmitter current or *analog output to Slave* is greater than the *trip point*.

Normal Trip Status Logic — Trip status output is high (+12 Vdc) and the trip LED on the front panel is ON when trip output is high (+24 Vdc). Trip status output is low (0 Vdc) and the trip LED on the front panel is OFF when trip output is low (0 Vdc).

Reset Differential — The difference between the *trip point* for an increasing input sensor signal and the *trip point* for a decreasing input sensor signal.

Reversed Trip Output Logic — It provides a low (0 Vdc) *trip output* when the transmitter current or *analog output to Slave* is greater than the *trip point*.

Reversed Trip Status Logic — Trip status output is high (+12 Vdc) and the trip LED on the front panel is ON when the trip output is low (0 Vdc). Trip status output is low (0 Vdc) and the trip LED on the front panel is OFF when trip output is high (+24 Vdc).

Slave Trip Unit — A *trip unit* which receives an analog voltage signal from a *Master Trip Unit*. It provides a *trip output* and a *gross failure output*.

Stable Calibration Current — An adjustable current with a limited slew rate. It is used to calibrate *trip points* on *trip units*.

Transient Blanking Signal — A voltage signal generated in the Calibration Unit used to blank the upper display on the Readout Assembly when *transient calibration current* is applied.

Transient Calibration Current — An adjustable current with a fast rise time. It is added to or subtracted from *stable calibration current* for time response measurements.

Transient Trigger Signal — A fast rise time voltage signal (accessible through a test jack J1, red) used to trigger an oscilloscope for time response measurements.

Trip Action — The change in the *trip output* which occurs when the input sensor signal or *analog output to Slave* passes through the *trip point*.

Trip Output — A voltage signal with reversible logic provided by *trip units* when the input sensor signal or *analog output to Slave* passes through the *trip point*.

Trip Point — The value of the input sensor signal or the *analog output to Slave* when the *trip action* occurs.

Trip Status LED — A light-emitting diode with reversible logic to indicate when the *trip status output* is high (12 Vdc).

Trip Status Output — A voltage signal with reversible logic used during calibration to latch the *trip point* on the upper display of the Readout Assembly.

Trip Unit — An electronic assembly which provides a *trip output* and a *gross failure output* from signals generated by transmitters, RTDs, or other trip units. The outputs can drive relays and external equipment. All Trip Units in the 710DU System have adjustments for high and low gross failure output, trip point, and reset differential.

Window Pulse — A logic signal generated in the Readout Assembly which determines how many clock-pulses are counted when *calibration current* is converted to a digital signal for display on the Readout Assembly.