Joseph H. Plona
Site Vice President

6400 N. Dixie Highway, Newport, MI 48166
Tel: 734.586.5910 Fax: 734.586.4172

DTE Energy

10 CFR 50.90

October 4, 2010
NRC-10-0073

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington D C 20555-0001

References: 1) Fermi 2
NRC Docket No. 50-341
NRC License No. NPF-43

2) Detroit Edison's Letter to NRC, "Proposed License Amendment to Revise the Degraded Voltage Function Requirements of Technical Specification Table 3.3.8.1-1 to Reflect Undervoltage Backfit Modification," NRC-09-0022, dated June 10, 2009

3) Detroit Edison's Letter to NRC, "Response to Request for Additional Information Regarding the Proposed License Amendment to Revise the Degraded Voltage Function Requirement of Technical Specification Table 3.3.8.1-1 to Reflect Undervoltage Backfit Modification," NRC-09-0054, dated September 16, 2009

4) Detroit Edison's Letter to NRC, "Response to Request for Additional Information Regarding the Proposed License Amendment to Revise the Degraded Voltage Function Requirements of Technical Specification Table 3.3.8.1-1 to Reflect Undervoltage Backfit Modification," NRC-10-0006, dated July 23, 2010

Subject: Transmittal of Revised Design Calculations for Setpoint Evaluation of Degraded Voltage Functions in Technical Specification Table 3.3.8.1-1

In Reference 2, Detroit Edison proposed a license amendment to the Fermi 2 Operating License to revise Technical Specification Table 3.3.8.1-1 to reflect changes resulting from a degraded voltage logic design modification developed to address an NRC backfit issue. The NRC reviewed the proposed license amendment and requested additional information that was provided in References 3 and 4. A setpoint design calculation (DC) was provided with Reference 4 that included setpoint evaluation for functions in Technical Specifications Table 3.3.8.1-1.

During a conference call between NRC staff and Detroit Edison personnel on September 29, 2010, the NRC noted that degraded voltage relay as-found tolerances are not evaluated in the design calculation provided with Reference 4. The setpoint design calculation has been revised to include as-found acceptance criteria and is hereby provided in the enclosure to this letter.

Should you have any questions or require additional information, please contact Mr. Rodney W. Johnson of my staff at (734) 586-5076.

Sincerely,

Joseph H. Plona

Enclosure:
Setpoint Calculations: DC-0919, Volume I DCD 1, Revision A

cc: NRC Project Manager
NRC Resident Office
Reactor Projects Chief, Branch 4, Region III
Regional Administrator, Region III
Supervisor, Electric Operators,
Michigan Public Service Commission

I, J. Todd Conner, do hereby affirm that the foregoing statements are based on facts and circumstances which are true and accurate to the best of my knowledge and belief.

J. Todd Conner
Director, Nuclear Generation

On this 4th day of October, 2010 before me personally appeared J. Todd Conner, being first duly sworn and says that he executed the foregoing as his free act and deed.

Notary Public

STACY OAKES
NOTARY PUBLIC, STATE OF MI
COUNTY OF MONROE
MY COMMISSION EXPIRES Jul 28, 2012
ACTING IN COUNTY OF MONROE

Enclosure to
NRC-10-0073

Fermi 2 NRC Docket No. 50-341
Operating License No. NPF-43

Transmittal of Revised Design Calculations for
Setpoint Evaluation of Degraded Voltage
Functions in Technical Specification Table 3.3.8.1-1

Setpoint Calculation: DC-0919, Volume I DCD 1, Revision A

DESIGN CALCULATION COVER SHEET

PART 1: DESIGN CALCULATION IDENTIFICATION				
A)	**Design Calculation Number DC-0919**		**B)**	**Volume Number I DCD 1**
C)	**Revision A**	**D) PIS Number R1400**	**E)**	**QA Level** [ ] Non-Q [X] 1 [ ] 1M
F)	**ASME Code Classification** [X] NA		**G)**	**Certification Required** [ ] Yes [X] No
H)	**Lead Discipline** Electrical		**I)**	**Incorporation Code** F
J)	**Title** Undervoltage Relay Setpoints			
K)	**Design Change Documents Incorporated (Number and Revision)** None			
L)	**Design Calculations Superseded (Number and Revision)** Vol I DCD-1 Rev. 0			
M)	**Revision Summary** See Page 2 for details			
N)	**Review of Assumptions, Methods, and Inputs Completed (Step 4.3.2)** ☐ Standard review, completed in revision ________ ☒ Key calculation review, completed in revision F ☐ Key Calculation Review/Upgrade ☐ Postponed ☐ Waived ________ PSE Manager's Signature ☐ N/A (Non-Q)			
O)	**PPRNs are required:** [X] Yes [ ] No Issuing DCD EDP 35621 Rev. A, ECR 35621-5 Rev. 0, ECR 36014-1 Rev. 0 [ ] N/A			
P)	**Key Calculation:** [X] Yes [ ] No Justification for Yes or No: This design calculation is listed on the Key Calc List.			
PART 2: PREPARATION, REVIEW, AND APPROVAL				
A)	**Prepared By** ☒ PSE-52 Qualified and additional qualifications per Step 2.3: ____ ☐ N/A Or ☐ Common-33 Qualified for EQRs Sign Patricia A. Uyorcek Date 10-01-2010			
B)	**Checked By** ☒ PSE-52 Qualified and additional qualifications per Step 2.3: ____ ☐ N/A Or ☐ Common-33 Qualified for EQRs Sign [signature] Date 10/01/2010			
C)	**Verified By** ☒ PSE-52 Qualified and additional qualifications per Step 2.3: ____ ☐ N/A Or ☐ Verification N/A (No verification required) Sign Billy Duffy Date 10-01-2010			
D)	Design Calculation Utility has been updated ☐ Yes ☐ N/A **Approved By** J. S. Dudlets Sign [signature] Date 10-4-2010			

Not Decommissioning Related

DTC: TPMMES DSN: MES15001 Rev. 8 P1/1 File: 1703.22 Issued: 10/ /10
DTC: TDPCAS ☐ TDPELE ☒ TDPINC ☐ TDPMEC ☐
DSN: DC-0919 Vol I DCD 1 Rev: A File: 1801 IP: I

Revision Summary

This revision removes the various load flow and motor starting calculations from this calculation. Calculations necessary to serve as boundary conditions for the various setpoints are now contained in Calculation DC-6447 (Ref. 8.2.14). Several attachments and appendices that are out of date or no longer applicable to this calculation have been removed. Tables 1 through 4 and Figures 1 through 3 have been removed because DC-6447 (Ref. 8.2.14) now provides the equivalent information.

This revision addresses the replacement of the Reactor Building 4160 V bus degraded voltage relays by EDP-35621 Rev. A (Ref. 8.2.18). In addition it applies the GE methodology from Report NEDC-31336P-A from DECO File C1-4180 (Ref. 8.2.1) to the determination of uncertainties, setpoints and allowable values for the relay settings.

This revision also revises the setpoint for the LPCI swing bus undervoltage relays based on Calculations DC-6447 (Ref. 8.2.14) and DC-5003 (Ref. 8.2.36).

This revision applies the LER avoidance test to the nominal trip setpoints and moves the nominal trip setpoints (NTSP) for the secondary undervoltage (degraded voltage) relays farther away from the lower Allowable Values to improve LER avoidance.

This revision determines as-found tolerances, which will be used to indicate possible performance degradation of the relays.

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1.0 Purpose and Objectives

Purpose

The primary purpose of this design calculation is to determine the undervoltage (UV) relay trip settings for plant safety-related buses for both Primary (Loss of Voltage, LOV) and Secondary (Degraded Voltage, DV) levels. Both safety Divisions of the Fermi 2 electrical system are analyzed to determine the Primary and Secondary undervoltage setpoints. The determination of the setpoints and associated reset values are based on meeting the requirements of PSB-1 (Ref 8.2.21) as it is applied to Fermi 2.

NRC-Branch Technical Position PSB-1 (Ref. 8.2.21) "Adequacy of Station Electric Distribution System Voltages" reconfirms the requirements for degraded grid and loss of off-site power relaying. The loss of voltage and degraded voltage relay settings are also required for the Technical Specifications Table 3.3.8.1-1.

Objective

The objective of the undervoltage scheme is to sense and respond to off-site voltage variations which affect the Fermi 2 auxiliary systems. The undervoltage schemes specifically address the loss of off-site power system voltage and voltage degradation of the off-site and on-site power system.

Two undervoltage schemes are employed on each Division to accomplish these objectives. The two undervoltage schemes are the primary for loss of off-site power (loss of voltage) and the secondary for degraded voltage levels. Operation of either scheme automatically isolates the associated divisional bus from the grid, sheds bus loads to prevent overloading the emergency diesel generators (EDG), and initiates both EDG and load sequencer start. NRC requirements are contained in Item 222.31A (Appendix A) which Fermi 2 has committed to implement.

2.0 Summary of Results

2.1 Setpoints and Allowable Values Summary

Division I	Voltage (% Nominal)	Scheme (Time Delay) (Seconds)	Section
**4160 Volt Buses (Reactor Bldg.) UV Alarm	98.0% (4076.8 V)	30.0	9.1.2
4160 Volt Buses (RHR Bldg.) Primary UV (Loss of Voltage)	54.0% (2247 V)	2.0 (Inverse Time) *	9.2.1
480 Volt Buses (Reactor & RHR Building) Primary UV (Loss of Voltage)	43.0% (206.4 V)	2.0 (Inverse Time) *	9.1.4, 9.2.2
480 Volt Buses (Swing Bus) Secondary UV (Degraded Voltage)	95.04% (456.21 V)	4.83 Max.	9.5.2

* This relay has an inverse time characteristic. See the time-voltage characteristics for type ITE 27D Type 211R4175 undervoltage relay (DC-2514, Ref. 8.2.22)

** See Table 3.3.8.1-1 Technical Specification (Ref 8.2.13)

The listed Analytical Limits (ALims) identified as "Min" or "Max" in the following tables are not necessarily the actual limits, but are the values closest to the Allowable Values (AVs) that can be supported by application of the DECO File C1-4180 (Ref. 8.2.1) methodology to the stated AVs. Actual ALims are identified in the voltage analysis (Ref. 8.2.14).

Division I Reactor Building 4160 V Buses Primary Undervoltage (Loss of Voltage) Relay Values

Results from Section 9.1.1			**P-P Relays**	**P-N Relays**
Division I Relays			XY-27A/64B YZ-27A/64B XY-27A/64C YZ-27A/64C	XN-27C/64B YN-27C/64B XN-27C/64C YN-27C/64C
Description	**Value, 4160 V bus, Volts**	**Value, % of 4160 Volts**	**Value, at Relay, Volts**	**Value, at Relay, Volts**
Min Upper ALim	≤ **3134.0**	≤ 75.3		
Upper AV	≤ **3093.7**	≤ 74.4	≤ 88.39	≤ 89.31
Max possible SetPt *	3090.2 ↓	74.3 ↓		
Operate NTSP (coil energized)	**3033.0 decreasing**	72.9 ↓	86.66 ↓	87.56 ↓
Min possible SetPt *	2975.8 ↓	71.5 ↓		
Lower AV	≥ **2972.3**	≥ 71.4	≥ 84.92	≥ 85.80
Max Lower ALim	≥ **2932.0**	≥ 70.5		
Reset NTSP (coil de-energized)	**3126.8 increasing**	75.2 ↑	89.34 ↑	90.26 ↑

* Max and Min SetPt that maintain required uncertainty between the ALim and NTSP.

The existing relay Operate NTSP (nominal trip setpoint, the actual desired operate setting of the relay) is bounded by the maximum and minimum possible setpoints that support the existing Technical Specification Allowable Values (AVs) in Table 3.3.8.1-1. The existing NTSP and AVs support the Analytical Limits shown.

Division I Reactor Building 4160 V Buses Primary Undervoltage (Loss of Voltage) Time Delay Relay Values

Results from Section 9.1.1		
Div I Relays	**Description**	**Value, in seconds**
XY-27A/64B YZ-27A/64B XY-27A/64C YZ-27A/64C XN-27C/64B YN-27C/64B XN-27C/64C YN-27C/64C	Minimum Upper ALim	≤ 2.27
	Upper AV	≤ 2.1
	NTSP	2.0 increasing
	Lower AV	≥ 1.9
	Maximum Lower ALim	≥ 1.73

The existing relay time NTSP is bounded by the existing Allowable Values in the Technical Specifications. The existing NTSP and Allowable Values support the Analytical Limits shown.

Division I Reactor Building 4160 V Buses Secondary Undervoltage (Degraded Voltage) Relay Values

Results from Section 9.1.2				
Division I Relays			**P-P Relays**	**P-N Relays**
			XY-27B/64B YZ-27B/64B XY-27B/64C YZ-27B/64C	YN-27D/64B ZN-27D/64B YN-27D/64C ZN-27D/64C
Description	**Value, 4160 V bus, Volts**	**Value, % of 4160 Volts**	**Value, at Relay, Volts**	**Value, at Relay, Volts**
Upper ALim*	**≤ 3972.8**	**≤ 95.5**		
Max possible Reset *	3964.6 increasing	95.3 ↑		
Upper AV * (& max possible SetPt)	**≤ 3944.8**	≤ 94.8	≤ 112.71	≤ 113.88
Operate NTSP (coil energized)	**3924.6 decreasing**	94.3 ↓	112.13 ↓	113.29 ↓
Min possible SetPt **	3908.8 decreasing	94.0 ↓		
Lower AV	**≥ 3904.4**	**≥ 93.9**	≥ 111.55	≥112.71
Lower ALim	**≥ 3873.0**	**≥ 93.1**		
Reset NTSP (coil de-energized)	**3944.3 increasing**	94.8 ↑	112.69 ↑	113.86 ↑

* The upper AV and upper ALim are not determined per the standard methodology of C1-4180 (Ref. 8.2.1), since it does not include the case of an upper limit for a descending actuation. The upper AV and ALim are determined as required to support the voltage analysis (Ref. 8.2.14). The upper AV is set at the maximum error above the NTSP, and represents the maximum expected actuation of the decreasing voltage trip. The upper ALim must be equal to or greater than the reset point of the upper AV.

** Min SetPt that maintains required uncertainty between the Lower ALim and NTSP.

New relay Operate NTSP and new lower Allowable Value have been determined to be separated from the lower Analytical Limit by the required channel uncertainty per DECO File C1-4180 (Ref. 8.2.1). The new relay Operate NTSP is greater than the minimum possible setpoint required for the lower ALim. The upper AV is set at the maximum possible setpoint actuation above the NTSP, by adding the entire channel error to the minimum NTSP. The maximum possible reset point is the highest value at which reset could occur if the relay Operates at the Upper AV (max setpoint). The maximum possible reset point is bounded by the Upper ALim. The Technical Specifications in Table 3.3.8.1-1 must be revised to incorporate the new Allowable Values.

Division I Reactor Building 4160 V Buses Secondary Undervoltage (Degraded Voltage) LOCA Time Delay Relay Values

Results from Section 9.1.3	
Description	XY-27B/64B YN-27D/64B YZ-27B/64B ZN-27D/64B XY-27B/64C YN-27D/64C YZ-27B/64C ZN-27D/64C
	seconds
Minimum Upper ALim	≤ 7.97
Upper AV	≤ 7.31
NTSP	6.7 increasing
Lower AV	≥ 6.16
Maximum Lower ALim	≥ 5.5

This calculation has demonstrated that adequate channel uncertainty exists between the setpoint and AVs, and between each AV and its associated ALim, in accordance with the methodology based on DECO File C1-4180 (Ref. 8.2.1).

Division I Reactor Building 4160 V Buses Secondary Undervoltage (Degraded Voltage) Non-LOCA Time Delay Relay Values

Results from Section 9.1.3		
Description	Total Time	1RU62 & 1RV62
	seconds	
Upper ALim + EDG relay limit	≤ 51.55	
Upper ALim	≤ 48.05	
Upper AV	≤ 46.2	≤ 38.891
NTSP	44.0 ↑	37.3 ↑
Lower AV	≥ 41.8	≥ 35.640
Lower ALim	≥ 39.96	

This calculation has demonstrated that adequate channel uncertainty exists between the setpoint and AVs, and between each AV and its associated ALim, in accordance with the methodology based on DECO File C1-4180 (Ref. 8.2.1).

Division II	**Voltage (% Nominal)**	**Scheme (Time Delay) (Seconds)**	**Section**
**4160 Volt Buses (Reactor Bldg.)			
UV Alarm	98.4% (4093.44V)	10.0	9.3.2
4160 Volt Buses (RHR Bldg.)			
Primary UV (Loss of Voltage)	54.0% (2247V)	2.0 (Inverse Time) *	9.4.1
480 Volt Buses (Reactor & RHR Building)			
Primary UV (Loss of Voltage)	43.0% (206.4 V)	2.0 (Inverse Time) *	9.3.4 9.4.2
480 Volt Buses (Swing Bus)			
Secondary UV (Degraded Voltage)	95.04% (456.21V)	4.83 Max	9.5.2

* This relay has an inverse time characteristic. See the time-voltage characteristics for type ITE 27D Type 211R4175 undervoltage relay (DC-2514, Ref. 8.2.22)

** See Table 3.3.8.1-1 Technical Specification (Ref 8.2.13)

The listed Analytical Limits (ALims) identified as "Min" or "Max" in the following tables are not necessarily the actual limits, but are the values closest to the Allowable Values (AVs) that can be supported by application of the DECO File C1-4180 (Ref. 8.2.1) methodology to the stated AVs. Actual ALims are identified in the voltage analysis (Ref. 8.2.14).

Division II Reactor Building 4160 V Buses Primary Undervoltage (Loss of Voltage) Relay Values

Results from Section 9.3.1			**P-P Relays**	**P-N Relays**
Division II Relays			XY-27A/65E YZ-27A/65E XY-27A/65F YZ-27A/65F	XN-27C/65E YN-27C/65E XN-27C/65F YN-27C/65F
Description	**Value, 4160 V bus, Volts**	**Value, % of 4160 Volts**	**Value, at Relay, Volts**	**Value, at Relay, Volts**
Min Upper ALim	**≤ 3179.9**	≤ 76.4		
Upper AV	**≤ 3139.6**	≤ 75.5	≤ 89.70	≤ 90.63
Max possible SetPt *	3136.1 ↓	75.4 ↓		
Operate NTSP (coil energized)	**3078.0 decreasing**	74.0 ↓	87.94 ↓	88.85 ↓
Min possible SetPt *	3019.9 ↓	72.6 ↓		
Lower AV	**≥ 3016.4**	≥ 72.5	≥ 86.18	≥ 87.08
Max Lower ALim	**≥ 2976.1**	≥ 71.5		
Reset NTSP (coil de-energized)	**3173.2 increasing**	76.3 ↑	90.66 ↑	91.60 ↑

* Max and Min SetPt that maintain required uncertainty between the ALim and NTSP.

The existing relay Operate NTSP (nominal trip setpoint, the actual desired operate setting of the relay) is bounded by the maximum and minimum possible setpoints that support the existing Technical Specification Allowable Values (AVs) in Table 3.3.8.1-1. The existing NTSP and AVs support the Analytical Limits shown.

Division II Reactor Building 4160 V Buses Primary Undervoltage (Loss of Voltage) Time Delay Relay Values

Results from Section 9.3.1		
Div II Relays	**Description**	**Value, in seconds**
XY-27A/65E YZ-27A/65E XY-27A/65F YZ-27A/65F XN-27C/65E YN-27C/65E XN-27C/65F YN-27C/65F	Minimum Upper ALim	≤ 2.27
	Upper AV	≤ 2.1
	Operate NTSP	2.0 increasing
	Lower AV	≥ 1.9
	Maximum Lower ALim	≥ 1.73

The existing relay time Operate NTSP is bounded by the existing Allowable Values in the Technical Specifications Table 3.3.8.1-1. The existing NTSP and Allowable Values support the Analytical Limits shown.

Division II Reactor Building 4160 V Buses Secondary Undervoltage (Degraded Voltage) Relay Values

Results from Section 9.3.2				
Division II Relays			**P-P Relays**	**P-N Relays**
			XY-27B/65E YZ-27B/65E XY-27B/65F YZ-27B/65F	YN-27D/65E ZN-27D/65E YN-27D/65F ZN-27D/65F
Description	**Value, 4160 V bus, Volts**	**Value, % of 4160 Volts**	**Value, at Relay, Volts**	**Value, at Relay, Volts**
Upper ALim*	**≤ 3918.7**	≤ 94.2		
Max possible Reset *	3718.4 increasing	89.4 ↑		
Upper AV * (& max possible SetPt)	**≤ 3699.8**	≤ 88.9	≤ 105.71	≤ 106.80
Operate NTSP (coil energized)	**3679.6 decreasing**	88.5 ↓	105.13 ↓	106.22 ↓
Min possible SetPt **	3663.8 decreasing	88.1 ↓		
Lower AV	**≥ 3659.4**	≥ 88.0	≥ 104.55	≥105.64
Lower ALim	**≥ 3628.0**	≥ 87.2		
Reset NTSP (coil de-energized)	**3698.1 increasing**	88.9 ↑	105.66 ↑	106.75 ↑

* The upper AV and upper ALim are not determined per the standard methodology of C1-4180 (Ref. 8.2.1), since it does not include the case of an upper limit for a descending actuation. The upper AV and ALim are determined as required to support the voltage analysis (Ref. 8.2.14). The upper AV is set at the maximum error above the NTSP, and represents the maximum expected actuation of the decreasing voltage trip. The upper ALim must be equal to or greater than the reset point of the upper AV.

* Min SetPt that maintains required uncertainty between the lower ALim and NTSP.

New relay Operate NTSP and new lower Allowable Value have been determined to be separated from the lower Analytical Limit by the required channel uncertainty per DECO File C1-4180 (Ref. 8.2.1). The new relay Operate NTSP is greater than the minimum possible setpoint required for the lower ALim. The upper AV is set at the maximum possible setpoint actuation above the NTSP, by adding the entire channel error to the NTSP. The maximum possible reset point is the highest value at which reset could occur if the relay Operates at the Upper AV (max setpoint). The maximum possible reset point is bounded by the Upper ALim. Technical Specifications Table 3.3.8.1-1 must be revised to incorporate the new Allowable Values.

Division II Reactor Building 4160 V Buses Secondary Undervoltage (Degraded Voltage) LOCA Time Delay Relay Values

Results from Section 9.3.3	
Description	XY-27B/65E YN-27D/65E YZ-27B/65E ZN-27D/65E XY-27B/65F YN-27D/65F YZ-27B/65F ZN-27D/65F
	seconds
Minimum Upper ALim	≤ 7.97
Upper AV	≤ 7.31
Operate NTSP	6.7 increasing
Lower AV	≥ 6.16
Maximum Lower ALim	≥ 5.5

This calculation has demonstrated that adequate channel uncertainty exists between the setpoint and AVs, and between each AV and its associated ALim, in accordance with the methodology based on DECO File C1-4180 (Ref. 8.2.1).

Division II Reactor Building 4160V Buses Secondary Undervoltage (Degraded Voltage) Non-LOCA Time Delay Relay Values

Results from Section 9.3.3		
Description	Total Time	1RW62 & 1RX62
	seconds	
Upper ALim + EDG relay limit	≤ 28.60	
Upper ALim	≤ 23.60	
Upper AV	≤ 22.47	≤ 15.161
Operate NTSP	21.35 ↑	14.65 ↑
Lower AV	≥ 20.33	≥ 14.169
Lower ALim	≥ 19.20	

This calculation has demonstrated that adequate channel uncertainty exists between the setpoint and AVs, and between each AV and its associated ALim, in accordance with the methodology based on DECO File C1-4180 (Ref. 8.2.1).

2.2 Calibration Information Summary

The calibration information used to support the results of this calculation is defined below. The field calibration setpoints (operate), reset points, and as-left tolerances are identified. The calibration procedures (Ref. 8.2.7, 8.2.8, 8.2.9 and 8.2.10) must be revised to conform to the stated settings. A new meter is specified for the voltage readings performed during the calibration. The existing digital timer is retained. The calculation results remain valid only for use of the specified M&TE or M&TE with better accuracy. Use of M&TE less accurate than those specified will invalidate the results of this calculation.

2.2.1 Primary Undervoltage (Loss of Voltage) Relays – Voltage Settings

Division I Primary UV (Loss of Voltage) Voltage P-P Relay Calibration Setpoints / Allowable Values:

Results from Section 9.1.1		
P-P Relays	**Parameter**	**Value, in Volts at Relay**
XY-27A/64B YZ-27A/64B XY-27A/64C YZ-27A/64C	Allowable Value - Upper	≤ 88.39 V
	Field Calibration Reset Point (coil de-energized)	89.34 V increasing
	Field Calibration Operate Setpoint (coil energized)	86.66 V decreasing
	Allowable Value – Lower	≥ 84.92 V

Division I Primary UV (Loss of Voltage) Voltage P-N Relay Calibration Setpoints / Allowable Values:

Results from Section 9.1.1		
P-N Relays	**Parameter**	**Value, in Volts at Relay**
XN-27C/64B YN-27C/64B XN-27C/64C YN-27C/64C	Allowable Value - Upper	≤ 89.31 V
	Field Calibration Reset Setpoint (coil de-energized)	90.26 V increasing
	Field Calibration Operate Setpoint (coil energized)	87.56 V decreasing
	Allowable Value – Lower	≥ 85.80 V

Division II Primary UV (Loss of Voltage) Voltage P-P Relay Calibration Setpoints / Allowable Values:

Results from Section 9.3.1		
P-P Relays	**Parameter**	**Value, in Volts at Relay**
XY-27A/65E YZ-27A/65E XY-27A/65F YZ-27A/65F	Allowable Value - Upper	≤ 89.70 V
	Field Calibration Reset Point (coil de-energized)	90.66 V increasing
	Field Calibration Operate Setpoint (coil energized)	87.94 V decreasing
	Allowable Value – Lower	≥ 86.18 V

Division II Primary UV (Loss of Voltage) Voltage P-N Relay Calibration Setpoints / Allowable Values:

Results from Section 9.3.1		
P-N Relays	**Parameter**	**Value, in Volts at Relay**
XN-27C/65E YN-27C/65E XN-27C/65F YN-27C/65F	Allowable Value - Upper	≤ 90.63 V
	Field Calibration Reset Setpoint (coil de-energized)	91.60 V increasing
	Field Calibration Operate Setpoint (coil energized)	88.85 V decreasing
	Allowable Value – Lower	≥ 87.08 V

Primary UV (Loss of Voltage) Calibration Frequency and Tolerances:

Surveillance Interval	As Left Tolerance	As-Found Tolerance
18 months	± 0.2 V	± 0.6 V

In order for these results to remain valid, the M&TE used to measure the voltage during the relay bench calibration must be either an Agilent 34401A, or a meter of equal or better accuracy. The calibration procedures (Ref. 8.2.7, 8.2.8, 8.2.9 and 8.2.10) must be revised to incorporate the new M&TE and tolerances.

2.2.2 Primary Undervoltage (Loss of Voltage) Relays – Time Settings

The calibration information used to support the results of this calculation is defined below. In addition, the field calibration setpoint and As Left Tolerance are identified.

Primary UV (Loss of Voltage) Time Calibration Setpoint / Allowable Value:

Results from Section 9.1.1			
		Parameter	**Value, in seconds**
XY-27A/64B YZ-27A/64B XY-27A/64C YZ-27A/64C XY-27A/65E YZ-27A/65E XY-27A/65F YZ-27A/65F	XN-27C/64B YN-27C/64B XN-27C/64C YN-27C/64C XN-27C/65E YN-27C/65E XN-27C/65F YN-27C/65F	Allowable Value - Upper	≤ 2.1
		Field Calibration Trip Setpoint	2.0 increasing
		Allowable Value – Lower	≥ 1.9

Primary UV (Loss of Voltage) Time Calibration Frequency and Tolerances:

Surveillance Interval	As-Left Tolerance	As-Found Tolerance
18 months	± 0.05 seconds	± 0.10 seconds

In order for these results to remain valid, the M&TE used to measure the time delay during the relay bench calibration must be either an SST-9203 digital timer, or a meter of equal or better accuracy. These values and the digital timer are not changed from what is in the existing calibration procedures (Ref. 8.2.7, 8.2.8, 8.2.9 and 8.2.10).

2.2.3 Secondary Undervoltage (Degraded Voltage) Relays – Voltage Settings

Division I Secondary UV (Degraded Voltage) Voltage P-P Relay Calibration Setpoints / Allowable Values:

Results from Section 9.1.2		
P-P Relays	**Parameter**	**Value, in Volts at Relay**
XY-27B/64B YZ-27B/64B XY-27B/64C YZ-27B/64C	Allowable Value - Upper	≤ 112.71 V
	Field Calibration Reset Point (coil de-energized)	112.69 V increasing
	Field Calibration Operate Setpoint (coil energized)	112.13 V decreasing
	Allowable Value – Lower	≥ 111.55 V

Division I Secondary UV (Degraded Voltage) Voltage P-N Relay Calibration Setpoints / Allowable Value:

Results from Section 9.1.2		
P-N Relays	**Parameter**	**Value, in Volts at Relay**
YN-27D/64B ZN-27D/64B YN-27D/64C ZN-27D/64C	Allowable Value - Upper	≤ 113.88 V
	Field Calibration Reset Setpoint (coil de-energized)	113.86 V increasing
	Field Calibration Operate Setpoint (coil energized)	113.29 V decreasing
	Allowable Value – Lower	≥ 112.71 V

Division II Secondary UV (Degraded Voltage) Voltage P-P Relay Calibration Setpoints / Allowable Values:

Results from Section 9.3.2		
P-P Relays	**Parameter**	**Value, in Volts at Relay**
XY-27B/65E YZ-27B/65E XY-27B/65F YZ-27B/65F	Allowable Value - Upper	≤ 105.71 V
	Field Calibration Reset Point (coil de-energized)	105.66 V increasing
	Field Calibration Operate Setpoint (coil energized)	105.13 V decreasing
	Allowable Value – Lower	≥ 104.55 V

Division II Secondary UV (Degraded Voltage) Voltage P-N Relay Calibration Setpoints / Allowable Value:

Results from Section 9.3.2		
P-N Relays	**Parameter**	**Value, in Volts at Relay**
YN-27D/65E ZN-27D/65E YN-27D/65F ZN-27D/65F	Allowable Value - Upper	≤ 106.80 V
	Field Calibration Reset Setpoint (coil de-energized)	106.75 V increasing
	Field Calibration Operate Setpoint (coil energized)	106.22 V decreasing
	Allowable Value – Lower	≥ 105.64 V

Secondary UV (Degraded Voltage) Calibration Frequency and Tolerances:

Surveillance Interval	As Left Tolerance	As-Found Tolerance
18 months	± 0.12 V	± 0.58 V

In order for these results to remain valid, the M&TE used to measure the voltage during the relay bench calibration must be either an Agilent 34401A, or a meter of equal or better accuracy. The calibration procedures (Ref. 8.2.7 – 8.2.10) must be revised to incorporate the new M&TE and tolerances.

2.2.4 Secondary Undervoltage (Degraded Voltage) Relays – LOCA Time Settings

The calibration information used to support the results of this calculation is defined below. In addition, the field calibration setpoints and expanded tolerances are identified.

Secondary UV (Degraded Voltage) LOCA Division I Time Calibration Setpoint / Allowable Value:

Results from Section 9.1.3		
Relays	**Parameter**	**Value, in seconds**
XY-27B/64B YZ-27B/64B XY-27B/64C YZ-27B/64C YN-27D/64B ZN-27D/64B YN-27D/64C ZN-27D/64C	Allowable Value - Upper	≤ 7.31
	Field Calibration Trip Setpoint	6.7 increasing
	Allowable Value – Lower	≥ 6.16

Secondary UV (Degraded Voltage) LOCA Division II Time Calibration Setpoint / Allowable Value:

Results from Section 9.3.3		
Relays	**Parameter**	**Value, in seconds**
XY-27B/65E YZ-27B/65E XY-27B/65F YZ-27B/65F YN-27D/65E ZN-27D/65E YN-27D/65F ZN-27D/65F	Allowable Value - Upper	≤ 7.31
	Field Calibration Trip Setpoint	6.7 increasing
	Allowable Value – Lower	≥ 6.16

Calibration Frequency and Tolerances

Surveillance Interval	As-Left Tolerance	As-Found Tolerance
18 months	± 0.5 seconds	± 0.54 seconds

2.2.5 Secondary Undervoltage (Degraded Voltage) Relays – Non-LOCA Time Settings

The calibration information used to support the results of this calculation is defined below. In addition, the field calibration setpoints and tolerances are identified.

Secondary UV (Degraded Voltage) Non-LOCA Division I Time Calibration Setpoint / Allowable Value (Agastats):

Results from Section 9.1.3		
	Parameter	**Value, in seconds**
1RU62 1RV62	Allowable Value - Upper	≤ 38.89
	Field Calibration Trip Setpoint	37.3 increasing
	Allowable Value – Lower	≥ 35.64

Calibration Frequency and Tolerances

Surveillance Interval	**As-Left Tolerance**	**As-Found Tolerance**
18 months	± 1.00 seconds	± 1.59 seconds

Secondary UV (Degraded Voltage) Non-LOCA Division II Time Calibration Setpoint / Allowable Value:

Results from Section 9.3.3		
	Parameter	**Value, in seconds**
1RW62 1RX62	Allowable Value - Upper	≤ 15.161
	Field Calibration Trip Setpoint	14.65 increasing
	Allowable Value – Lower	≥ 14.169

Calibration Frequency and Tolerances

Surveillance Interval	**As-Left Tolerance**	**As-Found Tolerance**
18 months	± 0.400 seconds	± 0.48 seconds

In order for these results to remain valid, the M&TE used to measure the time delay during the relay bench calibration must be either an SST-9203 digital timer, or a meter of equal or better accuracy. These values and the digital timer are not changed from what is in the existing calibration procedures (Ref. 8.2.7, 8.2.8, 8.2.9 and 8.2.10).

3.0 Methodology for Primary and Secondary (Degraded) Setpoints

3.1 Calculation Methodology

The calculation methodology from DECO File C1-4180 (Ref. 8.2.1) is used to determine the instrument accuracies and setpoints. Per this methodology, the relationship between the nominal trip setpoint (NTSP), Allowable Value (AV) and Analytical Limit (ALim) is defined in DECO File C1-4180 Part III, Sections 10.a and 10.b, as:

Ascending Process:

$$AV \leq ALim - (1.645/2)*(LAT^2 + LC^2 + PMA^2 + PEA^2)^{1/2} \pm Bias$$

$$NTSP \leq ALim - (1.645/2)*(LAT^2 + LC^2 + PMA^2 + PEA^2 + LDA^2)^{1/2} \pm Bias$$

Descending Process:

$$AV \geq ALim + (1.645/2)*(LAT^2 + LC^2 + PMA^2 + PEA^2)^{1/2} \pm Bias$$

$$NTSP \geq ALim + (1.645/2)*(LAT^2 + LC^2 + PMA^2 + PEA^2 + LDA^2)^{1/2} \pm Bias$$

See Section 6.0 for definitions of terms

3.1.1 LER Avoidance Test

The purpose of the LER Avoidance Test is to ensure that there is enough margin between the AV and the NTSP to avoid violations of the Allowable Values (AV). The LER avoidance probability of 90% is generally used as acceptance criterion (see Reference 8.2.1).

The LER Avoidance Test standard deviation (σ_{LER}) is determined by the errors present during calibration. The PMA and PEA uncertainties are not considered since during calibration a simulated signal is applied to the device input. σ_{LER} is the statistical combination of uncertainties of the channel accuracy (LAN, determined for normal environment), channel calibration accuracy (LC) and channel drift (LD). σ_{LER} is calculated as one sigma value. For a single channel, the Z_{LER} value that corresponds to 90% probability (or greater) is 1.29 (or greater). For multiple channels, the Z_{LER} value that corresponds to 90% probability (or greater) is 0.81 (or greater).

From C1-4180 (Ref. 8.2.1) Part III Section B.11:

$$Z_{LER} == \frac{|AV - NTSP|}{\sigma_{LER}} \qquad Z_{LERC} == \frac{|AV_C - NTSP_C|}{\sigma_{LER}} \qquad \sigma_{LER} = \frac{1}{2}\sqrt{(LAN^2 + LC^2 + LDa^2}$$

Z_{LER} is based on the existing AV and NTSP values. Z_{LERC} is based on calculated AV and NTSP values.

Additional margin will added to the minimum NTSP calculated per the base methodology of Section 3.1 above as needed to pass the LER avoidance test.

3.1.2 As-Found Tolerance

As-found tolerances will be determined for each setpoint, which can be used to indicate if the component is performing within its expected capabilities. The as-found tolerance will be determined as a combination of reference accuracy and drift, based on the APT (Acceptable Performance Tolerance) from C1-4180

(Ref. 8.2.1). The APT may conservatively be adjusted to be smaller than the maximum, in order to stay inside the Allowable Values, because this will result in an earlier indication of degraded performance. The APT will be initially determined as:

$$APT = \sqrt{(VA^2 + LD^2}$$

The NTSP ± APT will be compared to the AVs, and the APT will be reduced as needed to stay within the AVs.

3.2 Specific Methodology for Determination of Two Sided Allowable Values

The undervoltage relays are a unique case in the Technical Specifications, in that they have both an upper and a lower Allowable Value for a decreasing voltage setpoint, and an upper and a lower Allowable Value for an increasing time setpoint. Thus the DECO File C1-4180 (Ref. 8.2.1) methodology shown above is expanded to take this into account.

Loss of Voltage UV Relay (27D) Voltage Settings:

For the Loss of Voltage UV relay voltage AVs, the Technical Specification AVs are specified in Table 3.3.8.1-1 for a decreasing voltage setpoint, so the existing lower AV (AVL) is analyzed for acceptability using the standard formulas for a descending process as stated in Section 3.1. The existing AVL is used to compute a maximum lower analytical limit. This computed lower analytical limit is then used to compute a minimum NTSP using the standard formula for a descending process from Section 3.1. If the NTSP is equal to or greater than the minimum NTSP, then the NTSP is acceptable with respect to the lower ALim.

This method is expanded to address the upper AV (AVU) and analytical limit by applying the same formulas described in Section 3.1 above as though it were an ascending process trip. The minimum upper analytical Limit is computed by adding the combination of the non-drift errors to the existing AVU. Then the computed upper analytical limit is used to compute a maximum NTSP by subtracting the combination of all errors from the upper analytical limit. If the NTSP is equal to or less than the maximum NTSP, then the NTSP is acceptable with respect to the upper ALim.

Loss-of-Voltage UV Relay (27D) Time Settings:

For the Loss of Voltage UV relay time AVs, the Technical Specification AVs are specified for an increasing time setpoint, so the existing upper AV (AVU) is analyzed for acceptability using the standard formulas for an ascending process as stated in Section 3.1. The existing AVU is used to compute a minimum upper analytical limit. This computed upper analytical limit is then used to compute a maximum NTSP using the standard formula for an ascending process from Section 3.1. If the NTSP is equal to or less than the maximum NTSP, then the NTSP is acceptable with respect to the upper ALim.

This method is expanded to address the lower AV (AVL) and analytical limit by applying the same formulas described in Section 3.1 above as though it were a descending process trip. The maximum lower analytical limit is computed by subtracting the combination of the non-drift errors from the existing AVL. Then the computed lower analytical limit is used to compute a minimum NTSP by adding the combination of all errors to the lower analytical limit. If the NTSP is equal to or greater than the minimum NTSP, then the NTSP is acceptable with respect to the lower ALim.

Degraded Voltage UV Relay (27N) Voltage Settings:

This calculation determines new AVs and NTSPs for the degraded voltage UV relay voltages based on the new ALims provided by the voltage analysis (Ref. 8.2.14). Because the Technical Specification Table 3.3.8.1-1 AVs are for a decreasing voltage setpoint, the lower AV (AVL) and minimum NTSP are determined via the standard formulas for a descending process as stated in Section 3.1. The new NTSP is then chosen by rounding up the minimum NTSP.

In the case of the degraded voltage relay, the maximum possible reset point must be shown to be within the recovery voltage limits of the voltage analysis (Ref. 8.2.14). Because the reset is 0.5% of setting above the Operate NTSP, this maximum possible Operate NTSP is used to establish the upper AV (AVU) for the decreasing voltage trip. Thus the AVU is set at the NTSP plus the combination of all possible errors. The maximum Reset point is determined by dividing the AVU (max possible Operate NTSP) by 0.995 based on the 0.5% differential between operate and reset voltages. This maximum possible reset point must be less than or equal to the Upper Analytical Limit, which is the recovery voltage determined in the voltage analysis, (Reference 8.2.14).

Degraded Voltage UV Relay (27N) Time Settings:

The upper Alim for the LOCA time delay supports the 13 second EDG start time from the LOCA analysis (Ref. 8.2.19, UFSAR Tables 6.3-7 & 8.3-5). The EDG start circuit includes a separate time delay relay, and an additional 0.18 seconds is required to account for the closure times of the EDG output and RHR pump motor breakers. Thus the upper ALim for the DV LOCA time delay is determined by subtracting the maximum EDG start timer delay and 0.18 seconds from the 13 second EDG start time for LOCA. Although the EDG start timer relay is not in the Tech Spec, for conservatism, the standard methodology from C1-4180 (Ref. 8.2.1) is applied to determine the uncertainty of its actuation, and the resultant maximum and minimum time delays.

The Technical Specification Table 3.3.8.1-1 AVs for the LOCA condition degraded voltage relays are for an increasing time setpoint, so a new upper AV (AVU) is calculated via the standard formula for an ascending process as stated in Section 3.1. The lower ALim is conservatively chosen to be just above the Core Spray pump acceleration time (Ref. 8.2.14). The new lower AV (AVL) for LOCA conditions is calculated via the formula for a descending process as stated in Section 3.1, so the AVL will be separated from the lower ALim by the combination of all errors except drift. The new LOCA time NTSP is set then determined by setting it halfway between the AVL and AVU. The most restrictive (lowest) NTSP from either Division I or Division II is than applied to both divisions as the new LOCA Operate NTSP.

For non-LOCA conditions, the output of the ABB undervoltage relay (set at the LOCA time delay) starts a second Agastat timer relay. Thus the total non-LOCA time delay is the combination of the time delay from the degraded voltage undervoltage ABB relay (set at the LOCA time delay) and the time delay of the Agastat timer relay. The Technical Specification non-LOCA time AVs must be shown to bound the combination of the individual time AVs for the undervoltage relay plus the non-LOCA timer relay. The total NTSP for the non-LOCA time Operate NTSP is the undervoltage relay LOCA time Operate NTSP plus the timer relay Operate NTSP.

3.3 Conversion from 4160V Process Buses to 120V Relay Buses

Per References 8.2.25 – 8.2.28 there are two types of potential transformers that step down the voltage from the monitored 4160 V bus to the 120V relaying loop. The ratio of the input to output voltages is 4200/120 for the Phase to Phase (P-P) type and 2400/120 for the Phase to Neutral (P-N) type. Thus when converting specific voltage values from 4160 V to 120 V, 4200/120 is used for the P-P relays, and 2400 /120 is used for the P-N relays, because $2400 \approx 4160/\sqrt{3}$. The P-P 4200/120 conversion is slightly larger than the $(2400*\sqrt{3})$ /120 conversion, so all error terms are conservatively converted as 4200/120. Both the potential transformers and the relays are located within the switchgear cabinets, so no significant voltage drop is expected between the PT and the relays.

3.4 Methodology Considerations for Coordination between 480V Buses and 4160V Buses

The undervoltage relay settings for these buses are set to ensure adequate coordination between the 4160V and 480V buses with respect to time and loss of voltage settings.

Time Coordination

The Division 1 and 2 primary loss of voltage time delay (TD) setpoint selection will prevent false operation on normally expected transient disturbances. The UV device will coordinate with the overcurrent devices. The clearing time for the for the overcurrent device in which a fault depresses bus voltage will be less than the UV time delay. Under normal operating conditions the longest fault clearing time for the faults that will depress the voltage within the operating range of the UV relay are less than one second. A shorter time delay could cause an inadvertent grid separation due to a primary loss of voltage relay actuation. Evaluation of the coordination between overcurrent and undervoltage devices is provided in Ref. 8.2.22.

Loss of Voltage Coordination

The 4160V buses must trip first to prevent isolation of the 480V buses without EDG initiation. Loss of voltage at the 4160V buses initiates the EDGs. The 480V bus primary UV devices should coordinate with the 4160V primary device. There is typically a 2-3% voltage drop between the 480 and 4160V buses. Therefore to ensure selectivity, all 480V UV relays are set to account for the voltage drop bus difference. A higher trip setpoint could cause mis-coordination of relays which could lead to an inadvertent 480 volt bus separation due to a primary 480 volt loss of voltage relay actuation (Ref. 8.2.22).

4.0 Methodology Boundaries and Limitations

4.1 Boundaries

This calculation involves Divisions I and II safety-related buses only. These buses are specified below:

1. Reactor/Auxiliary Building 4160 Volts buses 64B, 64C, 65E and 65F:

   The 4160 Volts Reactor Building buses (64B, 64C, 65E and 65F) have primary and secondary (degraded) UV relays Protection (References 8.2.25 – 8.2.28).

2. RHR Building 4160 Volts Buses 11EA, 12EB, 13EC and 14ED:

   The 4160 Volts RHR building buses (11EA, 12EB, 13EC, and 14ED) are electrically part of the reactor building buses. The UV schemes for these buses are initiated by the 4160 Volts Reactor building UV schemes and, as such do not require separate UV monitors. Even so, separate primary UV devices are provided for each bus.

3. Reactor/Auxiliary/ RHR Building 480 Volts Buses 72B, 72C, 72E, 72F, 72EA, 72EB, 72EC and 72ED:

   Each of the above 4160 Volts buses (64B, 64C, 65E and 65F, 11EA, 12EB, 13EC, and 14ED) feeds one 480 Volts bus. The UV schemes for these 480 Volts buses are initiated by their respective 4160 Volts bus UV scheme and as such do not require separate UV monitors. Even so, separate primary UV devices are provided for each 480 Volts buses. The 480 Volts buses UV schemes perform the function of load shedding their respective bus only.

4. Operator action is taken when Divisional bus low voltage alarms ARP 9D22 and ARP 10D43 (References 8.2.29 and 8.2.30, respectively) are received. If the alarm cannot be corrected with the assistance of the grid operator and voltage further degrades then the operator action is to transfer the impacted Division to the EDGs prior to the trip actuation of the degraded under voltage relay.

4.2 Methodology Limitations

None

5.0 Assumptions

5.1 Unless specifically noted otherwise by the manufacturer, per the methodology of Ref. 8.2.1, calibration equipment accuracies are taken as three (3σ) values due to periodic calibration with high accuracy standards traceable to the National Bureau of Standards. Also per Ref. 8.2.1, the accuracy of the standards is conservatively assumed to be equal to twice the accuracy of the testing equipment, unless otherwise noted. This assumption is verified by conformance to Ref. 8.2.1. **Verified Assumption.**

5.2 The manufacturer does not state a drift effect for the ABB/ITE relays, model 27D and 27N. Per the Ref. 8.2.1 methodology, when the manufacturer does not state a drift, it can be assumed that the drift is included in the manufacturer's reference accuracy. In this calculation, for added conservatism, instead of assuming that the drift is included, a separate assumed drift effect of ±0.5 % of setpoint per refueling outage is applied for channel instrument drift. Attachment V includes multiple surveillances of observed as-left to as-found data for the Type 27D relay. The Type 27N is the high accuracy version of the Type 27, and so it is expected that its performance characteristics (including drift) are equal to or better than those of the 27D. Inspection of the data in this attachment shows that of the 224 cases, only 13 were found greater than 0.5% of setpoint. Thus 0.5% of setpoint is bounding for over 94% of the observed drift values. The observed drift, or difference in as-left to as-found values includes the combined effect of <u>all</u> uncertainties present during calibration, which are relay repeatability, calibration as-left tolerance, measurement and test equipment accuracy, and actual drift. Because the assumed drift value is applied only as drift, and the other error sources are applied separately within the calculation, it is conservative to assume the 0.5% of setting as a 2σ assumed drift value. The inspection of this data in Attachment V provides verification of this assumption. **Verified Assumption.**

There are no unverified assumptions.

6.0 Definitions of Terms

Primary Relaying: The primary loss of power undervoltage relay setpoints are defined such that anticipated transient voltages must not drop below the relay setpoints. Setpoints at this level should be selected to prevent false motor starting transient trips. When system transient voltages do fall below the established bus limits then the primary relay will activate and separate the Fermi 4160 V buses from offsite power.

Secondary Relaying: Secondary or Degraded voltage is defined as a level of voltage which is insufficient to operate safety-related loads but not low enough to operate the primary loss of off-site power protection. While operating at this voltage level is undesirable, analysis indicates that equipment will function without damage while voltage recovery is attempted. The associated time delays limit the time for the recovery attempt.

Primary Under Voltage (UV) Relays: These relays are set to trip on a complete Loss of Voltage. These relays are XY27A, YZ27A, XN27C and YN27C. Reference drawings are I-2572-28,29 (Ref. 8.2.25, 8.2.26) and I-2578-05,09 (Ref. 8.2.27, 8.2.28).

Secondary UV Relays: These relays are set to trip when the offsite voltage has degraded to the point where safety systems should not be operated. Continued operation under degraded voltage conditions may cause damage to Class IE equipment. These relays are XY27B, YZ27B, ZN27D and YN27D. Reference drawings are I-2572-28,29 (Ref. 8.2.25, 8.2.26) and I-2578-05,09 (Ref. 8.2.27, 8.2.28).

Secondary UV Relay (480V buses): A relay which is set to trip when the voltage on 480V swing bus fed from the Emergency Diesel Generator (EDG) has degraded to the point where the LPCI motor operated valves fed from swing bus MCC should not be operated as continued operation may cause damage to the valves.

ETAP: Computer program that models the electrical system within Fermi to analyze load flow bus voltages, Load Tap Changer (LTC) performance and motor starting conditions.

Division I: This is the section of the Fermi electrical distribution system that is connected to the 120 kV grid that serves the both safety related and balance of plant loads through SS64. SS64 contains a LTC which will maintain 4160 bus voltages at 100% for the range of UFSAR voltage limits.

Division II: This is the section of the Fermi electrical distribution system that is connected to the 345 kV grid that serves the safety related and balance of plant loads through SS65. SS65 does not have an LTC therefore all grid voltage variations will be transferred and seen on the 4160 bus voltages.

Instrument Uncertainty Analysis Abbreviations (from DECO File C1-4180, Ref. 8.2.1):

AK Instrument Accuracy under LOCA conditions - the SRSS (square-root-sum-squares) combination of inaccuracies associated with vendor accuracy (VA), accuracy temperature effect (ATEK) (LOCA environment conditions), overpressure effect (OPE), static pressure effect (SPE), power supply effect (PSE) and humidity effect (HE). AK does not include the inaccuracies of the calibrating equipment (CC), nor does it include the allowances for inaccuracies relative instrument drift (DD). AK is calculated as a 2-sigma value, unless otherwise noted. LAK is the channel instrument accuracy under LOCA conditions.

ALim Analytical Limit - The value of the sensed process variable established as part of the safety analysis prior to or at the point which a desired action is to be initiated to prevent the process variable from reaching the associated licensing safety limit.

ALT As Left Tolerance - The maximum precision with which the surveillance technician is required to calibrate (recalibrate) components. ALT is equal to the vendor accuracy (VA) of the component, unless otherwise noted. ALT is calculated as a 3-sigma value, unless otherwise noted.

APT Acceptable Performance Tolerance – A surveillance limit that determines whether or not a component is performing as expected. The maximum APT is based on the maximum expected error due to the SRSS of accuracy and drift. If the as-found value is within the APT, then the performance is acceptable. If the as-found value is within the APT, but exceeds the ALT, the performance is acceptable but the component must be recalibrated to be within the ALT. If the as-found value exceeds the APT, this is an indication that the component is not performing as expected and may be in need of maintenance or replacement.

ATE Accuracy Temperature Effect - Error due to external temperature changes (from the temperature of calibration to the temperature associated with the event of interest). ATEK is the post-LOCA Accuracy Temperature Effect.

AV Allowable Value - The Technical Specification value of the sensed process variable at which the trip setpoint may be found during surveillance.

AVU Upper Allowable Value - The upper Technical Specification value of the sensed process variable at which the trip setpoint may be found during surveillance.

AVL Lower Allowable Value - The lower Technical Specification value of the sensed process variable at which the trip setpoint may be found during surveillance.

Bias any bias, or non-random, error

CC Instrument Calibration Accuracy- The combination of inaccuracies associated with calibration equipment (CLI or CLO or both), calibration equipment standards (CSI or CSO or both), and the calibration procedure error (EP). These inaccuracies/allowances are considered to be independent variables. CC is calculated as a 2-sigma value, unless otherwise noted.

CIEK Channel Instrument Error LOCA: CIE is a prediction of the maximum error resulting from the effects of LA, LC, LD. PEA, PMA, ORE (Observer Readability Error), and Bias (such as IRA, Insulation Resistance Accuracy) that could reasonably exist at any time between surveillance tests. CIEK is the post-LOCA CIE. CIE is calculated as a 1.645-sigma value, unless otherwise noted.

CX Calibration Equipment Accuracy - The quality of freedom from error to which a perfect instrument could be calibrated assuming no error due to calibration procedure and considering only the error introduced by the inaccuracies of the calibration equipment (i. e., inaccuracy for Input Calibration Equipment (CLI) or inaccuracy for Output Calibration Equipment (CLO) or both). The calibration equipment's vendor inaccuracies, VAL and VAO are assumed equal to CLI and CLO, respectively. CLI and CLO are considered independent variables. CX is calculated as a 3-sigma value.

EAV Minimum error that separates the Allowable Value from the Analytical Limit. It is the combination of all channel errors except for drift. The random errors are combined via SRSS and taken to a 1.645 σ level, and bias (non-random) errors are added.

EP Calibration Procedure Effect - EP covers errors inherent in, or created by, the calibration process. EP is calculated as a 3-sigma value, unless otherwise noted. EP is equal to the larger of the ALT of the instruments being calibrated or the calibration equipment accuracy (CX), unless otherwise noted.

LAT Channel Accuracy for Desired Trip Conditions. For LOCA conditions, this is represented as LAK.

LC Channel Calibration Accuracy - The quality of freedom from error to which the nominal trip setpoint of a channel can be calibrated with respect to the true desired setpoint, considering only the errors introduced by the inaccuracies of the calibrating equipment used as the standards or references and the allowances for errors introduced by the calibration procedures. The accuracy of the different devices utilized to calibrate the individual channel instruments is the degree of conformity of the indicated values of these standards or references to the true, exact or ideal values. LC is the SRSS combination of instrument calibration inaccuracies (CC) of all of the equipment selected to calibrate the actual monitoring and trip devices of an instrument channel and includes the allowances for inaccuracies of the calibration procedures. LC is considered an independent variable. LC is calculated as a 2-sigma value unless otherwise noted.

LD Channel Drift - The change in the measured value of the process variable, due to all causes, between the time the channel is calibrated and a subsequent surveillance test. LD is an independent variable. LD is the SRSS combination of instrument drift inaccuracies (DD) of all components in the channel that are used to monitor the process variable and/or provide the trip functions. LD is calculated as a 2-sigma value, unless otherwise noted.

LER Licensee Event Report - A report which must be filed with the NRC by the utility when a Technical Specification limit is known to be exceeded, as required by 10CFR50.73.

NTSP Nominal Trip Setpoint - The limiting value of the sensed process variable at which a trip action may be set to operate at time of calibration.

PEA Primary Element Accuracy (random) - The inaccuracy of the channel component (exclusive of the sensor) that contacts the process, and quantitatively converts the measured variable energy into a form suitable for measurement (e.g., the orifice plate, adjacent parts of the pipe and the pressure connections constitute the primary element). PEA is calculated as a 2-sigma value, unless otherwise noted.

PMA Process Measurement Accuracy (random) - Process variable measurement effects (e.g., the effects of changing fluid density on the level measurement due to the process pressure and temperature change or the environment surrounding the impulse lines) aside from the primary element and sensor. These are uncertainties induced by the physical characteristics or properties of the process that is being measured. PMA is calculated as a 2-sigma value, unless otherwise noted. PMA may include the error contributions due to the readability of significant digits during calibration of the sensor and the number of digits provided in the calibration tables.

PSE Power Supply Effect (PSE): Error due to power supply fluctuations.

VA Vendor Accuracy – the inherent error of the device under ideal conditions as specified by the manufacturer

7. 0 Loading Conditions

Calculation DC-6447 "Auxiliary Power System Analysis" (Ref. 8.2.14) provides the boundary conditions for the setpoints. The following load conditions are applied.

Primary Loss of Voltage Relay:

- Mode 1 100% power operations, degraded grid conditions, largest switchyard drop and a start of a Heater Feed Pump.
- LOCA, degraded grid conditions, largest switchyard drop

Degraded Undervoltage Relay:

- LOCA, degraded grid conditions, largest switchyard drop
- Mode 1, 100% power operation, Buses 64B, 64C, 65E and 65F at the analytical limit
- Steady State LOCA, Buses 64B, 64C, 65E and 65F at the analytical limit

8.0 Design Inputs and Document Interface Reference Summary

8.1 Design Inputs

8.1.1 From Ref. 8.2.2 the potential transformers in the 4160V switchgear are ANSI Accuracy Class 0.3.

8.1.2 Relay Data – for ABB ITE Type 27D Model 211R4175 and Type 27, data is per Ref. 8.2.3, unless noted otherwise

The model number means single phase undervoltage relay in standard case, definite time characteristic adjustable from 1-10 sec, voltage tap range from 60-110Vac, control voltage range 48/125Vdc, 2 form C output contacts.

Differential between operate and reset voltage:	approximately 3% above
Operating temperature range	-30 to +70 °C
Control power allowable variation	100-140 Vdc
Repeatability (with no change in control voltage or ambient temperature)*	± 0.2 V
Control Power Repeatability Effect	± 0.2 V per 10V change in control power
Ambient Temperature Repeatability Effect	± 0.5 V over 20-40°C
Time Delay Repeatability	± 10% of setting

* Voltage Repeatability per Ref. 8.2.35 (E-mail from ABB, included as Att. Q)

8.1.3 Relay Data – for ABB ITE Type 27N Model 211T4175-HF-1E, data per Ref. 8.2.4

The model number means single phase undervoltage relay in a standard case, definite time characteristic adjustable from 1-10 sec, voltage tap range from 60-110Vac, control voltage range 48/125Vdc, 2 form C output contacts, with harmonic filter.

Differential between operate and reset voltage:	adjustable down to 0.5%, when on 99% tap
Operating temperature range	-30 to +70 °C
Control power allowable variation	100-140 Vdc
Repeatability (with no change in control voltage or ambient temperature)*	± 0.1%
Control Power Repeatability Effect	± 0.1% over the allowable control power range
Ambient Temperature Repeatability Effect (with harmonic filter option)	± 0.75% over 0 to 55 °C ± 0.40% over 10 to 40 °C
Time Delay Repeatability	± 10% of setting

8.1.4 Relay Data Agastat Type E7012PD, data per Ref. 8.2.15 (Att. U) & 8.2.16 (Att. G)

The model number means Nuclear Safety Related, 7000 Series Timing Relay, On-Delay, 2 double pole – double throw output contacts, 120Vdc Coil, 5 to 50 sec time range.

E7012 Repeat Accuracy	± 10% of setting
7012 Repeat Accuracy	± 5% of setting

Per Reference 8.2.17 (included as Attachment P), the E7012 is physically assembled from the same parts as the non-nuclear qualified 7012. The larger repeat accuracy of 10% reflects the combination of the repeat accuracy and harsh environmental testing. Thus if an E7012 is not subject to the harsh environment, its base repeat accuracy is equal to that of the industrial model 7012 (±5% of setting). 100% of the population of E7012s and 7012s are tested to verify their actuation within specified limits before shipping. Thus the specified repeat accuracy may be considered a 3σ confidence level.

8.1.5 Per Reference 8.2.5, the relays are located in the bus 64B/C and 65E/F switchgear, which are located in the Div I and Div II switchgear rooms. Per Ref. 8.2.6, pages 43 and 47, these are mild environmental zones, with normal maximum temperatures of 91°F and 95°F (respectively) but after LOCA with an HVAC failure, these zones may reach a maximum temperature of 120°F (49°C).

8.1.6 Based on 8.1.5 above, the E7012s are located in the switchgear room, which is a mild environment, so the ±5% of setting repeat accuracy of the 7012 will be applied to a 3σ confidence level.

8.1.7 Per Ref. 8.2.7 through 8.2.10, the existing relays are bench calibrated by measuring the voltage with a Fluke 8060A (200Vac range) and the time delay with an SST-9203 Digital Timer. The existing voltage as left tolerance (ALT) for all relays is ± 0.5 Vac. The existing time as left tolerance (ALT) is ±0.05 seconds. The existing setpoints are:

	Division I	Division II
4.16 kV Emergency Bus UV (Loss of Voltage)		
Bus Undervoltage	3033.0 V decreasing	3078.0 V decreasing
Time Delay	2 sec increasing	2 sec increasing
4.16 kV Emergency Bus UV (Degraded Voltage)		
Bus Undervoltage *	3952.0 V decreasing	3702.0 V decreasing
Time Delay w/o LOCA	44.0 sec increasing	21.4 sec increasing
Time Delay w/ LOCA *	8 sec increasing	8 sec increasing

* These setpoints will be changed by output of this calculation.

8.1.8 Per Reference 8.2.11, the following data is applicable to the Agilent 34401A Multimeter:

Range 1.000000 to 750.000 V, for measurement of True RMS AC Voltage of 120 volts.

Accuracy, for calibration of up to 1 year: ±0.06% of reading + 0.03% of range.

Per Reference 8.2.12, the Agilent 34401A accuracy specifications have a 4σ confidence level. They will be applied conservatively within this calculation as 3σ values.

8.1.9 Per Reference 8.2.13, the existing AVs for the UV relays are:

	Division I		Division II	
4.16 kV Emergency Bus UV (Loss of Voltage)				
Bus Undervoltage	≥ 2972.3 V	≤ 3093.7 V	≥ 3016.4 V	≤ 3139.6 V
Time Delay	≥ 1.9 sec	≤ 2.1 sec	≥ 1.9 sec	≤ 2.1 sec
4.16 kV Emergency Bus UV (Degraded Voltage)				
Bus Undervoltage *	≥ 3873.0 V	≤ 4031.0 V	≥ 3628.0 V	≤ 3776.0 V
Time Delay w/o LOCA	≥ 41.8 sec	≤ 46.2 sec	≥ 20.33 sec	≤ 22.47 sec
Time Delay w/ LOCA*	≥ 7.6 sec	≤ 8.4 sec	≥ 7.6 sec	≤ 8.4 sec

* These AVs will be changed by output of this calculation.
** Current AVs from LAR. These will be changed by output of this calculation.

8.1.10 Reference 8.2.14 has the following upper and lower degraded voltage Analytical Limits:

	Division I		Division II	
Upper ALim	95.5 %	3972.8 V	94.2 %	3918.7 V
Lower ALim	93.1 %	3873.0 V	87.2 %	3628.0 V

8.1.11 Reactor Building 4160V Bus Relay Channel Definitions

8.1.11.1 Channel Description

For each 4160V Reactor Building bus 64B, 64C, 65E and 65F, the bus voltage is monitored via a potential transformer that supplies a 120V relay bus and undervoltage relays that monitor the bus voltage. When the bus voltage decreases to the Operate setpoint, the relay output contacts actuate after a short time delay. The relay output contacts isolate the Class 1E buses from the off site source and start the diesel. If the reset point is reached before completion of the time delay, then the relay resets and the output contacts do not change state.

For loss of voltage, the loss of voltage undervoltage relay provides the required time delay. For degraded voltage, the degraded voltage relay provides the required time delay for the coincident LOCA case. In the case of degraded voltage without LOCA, after the LOCA time delay is fulfilled, then the actuation of the undervoltage relay contacts will initiate a second timer relay, which actuates after an additional delay. The total non-LOCA time delay is the combination of the LOCA time delay plus the non-LOCA timer relay delay.

<u>Channel 1 – Primary Undervoltage Relays (Loss of Voltage)</u>

Technical Specification Table 3.3.8.1-1, Loss of Power Instrumentation, functions 1.a and 1.b

<u>Channel 2 – Secondary Undervoltage Relays (Degraded Voltage)</u>

Technical Specification Table 3.3.8.1-1, including License Amendment Request to include LOCA time function, Loss of Power Instrumentation, functions 2.a, 2.b and 2.c

Required with and without LOCA

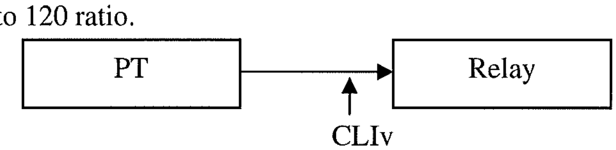
8.1.11.2 Channel Elements (Ref. 8.2.5 & 8.2.18)

Ch. No.		Div.	Potential Transformer	Relay Numbers	Manufacturer/Model
1-1	Loss of Voltage	I	Phase to Phase 4200 to 120 ratio	XY-27A/64B XY-27A/64C YZ-27A/64B YZ-27A/64C	ABB Type 27D Model 211R4175
			Phase to Neutral 2400*√3 to 120	XN-27C/64B XN-27C/64C YN-27C/64B XN-27C/64C	ABB Type 27D Model 211R4175
			Non-LOCA Time	1RU62	Agastat E7012PD
1-2	Loss of Voltage	II	Phase to Phase 4200 to 120 ratio	XY-27A/65E XY-27A/65F YZ-27A/65E YZ-27A/65F	ABB Type 27D Model 211R4175
			Phase to Neutral 2400*√3 to 120	XN-27C/65E XN-27C/65F YN-27C/65E YN-27C/65F	ABB Type 27D Model 211R4175
			Time	1RV62	Agastat E7012PD
2-1	Degraded Voltage	I	Phase to Phase 4200 to 120 ratio	XY-27B/64B XY-27B/64C YZ-27B/64B YZ-27B/64C	ABB Type 27N Model 211T4175-HF-1E
			Phase to Neutral 2400*√3 to 120	YN-27D/64B YN-27D/64C ZN-27D/64B ZN-27D/64C	ABB Type 27N Model 211T4175-HF-1E
			Time	1RW62	Agastat E7012PD
2-2	Degraded Voltage	II	Phase to Phase 4200 to 120 ratio	XY-27B/65E XY-27B/65F YZ-27B/65E YZ-27B/65F	ABB Type 27N Model 211T4175-HF-1E
			Phase to Neutral 2400*√3 to 120	YN-27D/65E YN-27D/65F ZN-27D/65E ZN-27D/65F	ABB Type 27N Model 211T4175-HF-1E
			Time	1RX62	Agastat E7012PD

8.1.11.3 Channel Diagram

Relay Voltage Channel:

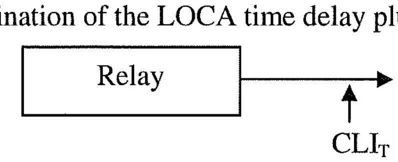
Each channel consists of a relay that monitors the voltage output from a potential transformer (PT). There are two types of PTs: phase to phase (P-P) with a 4200 to 120 ratio, and phase to neutral (P-N) with a 2400 to 120 ratio.



The input voltage decreasing to the Operate setpoint initiates a time delay. After completion of the time delay, then the relay output contacts change state. If the reset point is reached before completion of the time delay, then the relay resets and the output contacts do not change state.

In the case of the degraded voltage relay, for a LOCA coincident with degraded voltage, the required LOCA time delay is provided by the undervoltage relay. In the case of degraded voltage without LOCA, after the LOCA time delay is fulfilled, then the actuation of the undervoltage relay will initiate a second timer relay, which actuates after an additional delay. The total non-LOCA time delay is the combination of the LOCA time delay plus the non-LOCA timer relay delay.

The time channel is:



8.1.12 DC-6447 (Reference 8.2.14) provides the following design inputs:

Div. I LOCA minimum recovery voltage during transient	95.5 % of 4160V
Div. I momentary bus voltage from motor start transient	78.9% of 4160V
Div. II momentary bus voltage from motor start transient	82.3% of 4160V
Div II LOCA minimum recovery voltage during transient	94.2% of 4160V
Voltage recovery times for RHR and CS pump motor start	5.1 sec maximum – use 5.5 sec as lower ALim
Transformer 64 LTC voltage regulator control band	4142.8 V – 4306.8 V
Voltage recovery Time for Heater Feed Pump Start	9 seconds

8.1.13 DC Control Power Range

Per UFSAR Section 8.3.2.1.1 the 130 Vdc Division I and II ESF buses are protected from overvoltage by deactivating the rectifier bridge if the voltage exceeds 138.5 V. Per UFSAR Section 8.3.2.2, the batteries must be able to carry all required loads for 4 hours without battery voltage dropping below 210 Vdc (105 Vdc on the 130 Vdc buses). Although the bus voltage is monitored at the source, and it would be expected that the actual bus voltage at the relay locations would be lower, it is the range of control power variation (138.5 Vdc – 105 Vdc) that is used to determine the control power error effect for the relays (Inputs 8.1.2 and 8.1.3). Thus the control power error effect for the relays is calculated over the 105 to 138.5 Vdc range.

8.1.14 Per Reference 8.2.20, the following data is applicable to the Megger SST-9203 digital timer:

Range: 0.0001 to 99.9999 seconds

Least Significant Digit (LSD): 0.0001 second

Accuracy: larger of LSD or 0.005% of reading

8.1.15 The following design inputs pertain to the swing bus:

Design Input	Value/Information	Source
Overcurrent device response time	1 second	DC-2514 Vol. I (Ref. 8.2.22)
Load Sequencer time delay for swing bus	5 seconds	Ref. 8.2.23, 8.2.24
QA-1 motors locked rotor withstand time	15 seconds	DC-6348 Vol I (Ref. 8.2.36)
ABB (ITE) 27 Relay response time (Swing bus UV relays)	0.2 to 1.3 seconds ± 10%	Attachment B (Ref. 8.2.3)
Voltage drop from Bus 72C to MCC 72C-F	3V	DC-5003 Vol I (Ref. 8.2.36)
Voltage drop from Bus 72F to MCC 72C-F	4V	DC-5003 Vol I (Ref. 8.2.36)
Minimum Voltage at MCC 72C-F with 4kV bus voltage @ the analytical limit	93.07% of 480V	DC-6447 Vol I (Ref. 8.2.14)
EDG Voltage Regulator Tolerance	±1/2 %	VME8-2.2 (Ref. 8.2.37)
Bus 72C voltage with EDG @ 4100V	476V	DC-5003 Vol I (Ref. 8.2.36)

8.2 Document Interface Reference Summary:

Ref #	DTC	DSN or Document Type	Rev	Title	Ref	In put	Out put	How document is used in calculation
8.2.1	TDPINC	C1-4180	B	Setpoint Validation Guidelines	☐	☒	☐	Methodology for instrument loop accuracy & Tech Spec. AV determination
8.2.2	TS DSGN	3071-034	0	4160 Volt Indoor Metal Clad Switchgear for Enrico Fermi Atomic Power Plant, Unit 2 (Item 20.5 p. 11&12)	☐	☒	☐	PTs are ANSI Standard Accuracy Class 0.3
8.2.3	TMINSL	VMR1-67	A	Instructions Single Phase Voltage Relays – Undervoltage Relays and Overvoltage Relays	☐	☒	☐	Input data for ABB Type 27D Relays. ABB IB 18.4.7-2 Rev. E (included as Att. B)
8.2.4	TMINSL	VMC6-8	0	Type 27N and 59N High Accuracy Undervoltage Relay	☐	☒	☐	Input data for ABB Type 27N Relays – ABB IB 7.4.1.7-7 Rev. E (included as Att. O)
8.2.5	TLEQIP	CECO	0	Central Component (CECO) Database	☐	☒	☐	Relay manufacturer, model and location
8.2.6	TEGEN	EQ0-EF2-018	K	Summary of Environmental Parameters Used for the Fermi 2 EQ Program	☐	☒	☐	EQ Zone environmental data
8.2.7	TPNPP	42.302.07	33	Calibration and Functional Test of Division I 4160 Volt Bus 64B Undervoltage Relays	☐	☒	☒	Existing cal data – must be revised to reflect new Stpts, ALT, AVs & cal. equip.
8.2.8	TPNPP	42.302.08	34	Calibration and Functional Test of Division I 4160 Volt Bus 64C Undervoltage Relays	☐	☒	☒	Existing cal data – must be revised to reflect new Stpts, ALT, AVs & cal. equip.
8.2.9	TPNPP	42.302.09	32	Calibration and Functional Test of Division II 4160 Volt Bus 65E Undervoltage Relays	☐	☒	☒	Existing cal data – must be revised to reflect new Stpts, ALT, AVs & cal. equip.
8.2.10	TPNPP	42.302.10	32	Calibration and Functional Test of Division II 4160 Volt Bus 65F Undervoltage Relays	☐	☒	☒	Existing calibration data – must be revised to reflect new Stpts, ALT, AVs & cal. equip.
8.2.11		VENDOR CATALOG		Agilent 34401A Multimeter Product Overview	☐	☒	☐	Voltage measurement uncertainty (included as Att. R) Used in App. H
8.2.12		VENDOR CATALOG		Agilent Op Manual	☐	☒	☐	voltage measurement uncertainty (pages included as Att. S) Used in App. H
8.2.13	TSTECH	Tech Specs & Bases		Technical Specifications and Bases, including LAR for LOCA time delay	☐	☒	☒	TS Table 3.3.8.1-1 provides voltage surveillance limits. LAR changes required for new AVs
8.2.14	TDPELE	DC-6447		Auxiliary Power System Analysis	☐	☒	☐	Provides ALims for UV relays
8.2.15	TMINSL	VMR4-9	C	Agastat 7000 Series Industrial Electropneumatic Timing Relay	☐	☒	☐	Input data for 7000 Series Relays (included as Attachment U)
8.2.16	TMINSL	VMR4-9	C	Agastat Nuclear Qualified Time Delay Relays	☐	☒	☐	Input data for E7000 Series relays (included as Att. G)
8.2.17				E-Mail Correspondence, P. Ugorcak (URS) & R. Sinclair (Agastat – Tyco) 6-16-2010	☐	☒	☐	Acceptable to use 7000 series error for E7000 series relays (included as Attachment P)

Ref #	DTC	DSN or Document Type	Rev	Title	Ref	In put	Out put	How document is used in calculation
8.2.18		EDP-35621	A	Degraded Voltage Improvements	☐	☒	☒	Replaces DV relays with Type 27N, utilizes DV relay time delay for LOCA, changes Agastat time limit for non-LOCA – must include settings output from this calc
8.2.19	TDFSAR	UFSAR	16	Fermi 2 Updated Final Safety Analysis Report Table 6.3-7&8.3-5	☐	☒	☐	13 sec EDG start time in Section 3.2
8.2.20		VENDOR CATALOG		Megger SST-9203 Sold State Digital Timer	☐	☒	☐	time measurement uncertainty (included as Attachment T) used in Appendix H
8.2.21		PSB-1		NRC Branch Technical Position Adequacy of Station Electric Distribution System Voltages	☒	☐	☐	Provides UV protection requirements
8.2.22	TDPELE	DC-2514, Vol. I	B	Overcurrent vs. undervoltage protective relaying	☐	☒	☐	Verifies coordination of relaying between overcurrent and undervoltage relays
8.2.23		PRET R3000.003		Preoperational EDG testing	☐	☒	☐	Test results in Attachment D verify large motor starting dip
8.2.24	VSSERC	SE 89-0186	0	480V Swing Bus Motor Control Center	☐	☒	☐	Total time for ECCS injection
8.2.25	DDDINC	I-2572-28	R	Schematic Diagram 4160V ESS Buses #64B AND 64C – Load Shedding Strings	☐	☒	☐	Illustrates Division 1 load shedding string
8.2.26	DDDINC	I-2572-29	M	Schematic Diagram 4160V ESS Buses #65E & 65F Load Shedding Strings	☐	☒	☐	Illustrates Division 2 load shedding string
8.2.27	DDDINC	I-2578-05	O	Relaying & Metering Diag-4160V ESS Bus 64B	☐	☒	☐	Indicates location of relay connection
8.2.28	DDDINC	I-2578-09	N	Relaying & Metering Diag-4160V ESS Bus 65E	☐	☒	☐	Indicates location of relay connection
8.2.29	TRARP	9D22	14	Division I Bus Voltage Low	☐	☒	☐	Defines operator actions on degraded voltage
8.2.30	TRARP	10D43	13	Division II Bus Voltage Low	☐	☒	☐	Defines operator actions on degraded voltage
8.2.31	CMDEID	EF2-72330		Field Verification of Analytical Tech & Assumptions for EF2	☐	☒	☐	Verifies the starting motor voltage dip levels correlate to the analytical methods and assumptions for Onsite AC power systems. Contains the actual field test results of PRET.R1102.001.
8.2.32	TDPELE	DC-5003 Vol. I	I	Emergency Diesel Generator Loads Calculations	☐	☒	☐	Supplies LOCA loading values.
8.2.33	DDDINC	I-2714035	K	EDG Load Sequence Division I EDG #11 and 12	☐	☒	☐	Verifies the order of energized safety loads
8.2.34	DDDINC	I-2714-36	K	EDG Load Sequence Division II EDG #13 and 14	☐	☒	☐	Verifies the order of energized safety loads
8.2.35				E-Mail Correspondence, D. Steltz (ABB) to P. Ugorcak (URS) 5-25-2010	☐	☒	☐	Defines repeatability of ABB Type 27D relay (included as Attachment Q)

Ref #	DTC	DSN or Document Type	Rev	Title	Ref	In put	Out put	How document is used in calculation
8.2.36	TDPELE	DC-5003 Vol I	I	Emergency Diesel Generator Loads Calculation	☐	☒	☐	Determines voltage drop to MCC 72C-F,
8.2.37	TMINSL	VME8-2.2	0	Basler Electric Instruction Manual for Generator Excitation System	☐	☒	☐	Determines EDG voltage regulator tolerance
8.2.38	TDPELE	DC-6348 Vol I		OL1 MOV Thermal Overload Heater Sizing	☒	☐	☐	Verifies the withstand time for locked rotor conditions.
8.2.39	TPNPP	35.318.008	30	ITE Voltage Relay Testing	☒	☐	☐	Verifies proper pickup, dropout and time response operation of voltage relay.
8.2.40	DDDINC	I-2570-01	D	Functional Logic Diagram Operation of Power Line Feed & Tie Breakers 4160V Buses #64B & 11EA	☐	☒	☐	Shows multiple channel relay logic
8.2.41	DDDINC	I-2570-02	F	Functional Logic Diagram Operation of Power Line Feed & Tie Breakers 4160V Buses #64C & 12EB	☐	☒	☐	Shows multiple channel relay logic
8.2.42	DDDINC	I-2570-03	E	Functional Logic Diagram Operation of Power Line Feed & Tie Breakers 4160V Buses #65E & 13EC	☐	☒	☐	Shows multiple channel relay logic
8.2.43	DDDINC	I-2570-04	D	Functional Logic Diagram Operation of Power Line Feed & Tie Breakers 4160V Buses #65F & 14ED	☐	☒	☐	Shows multiple channel relay logic

9.0 Details of Calculation

9.1 Setpoint Determination and Acceptance Criteria for Division I Reactor Building

9.1.1 Division I Reactor Building 4160V Primary Undervoltage (Loss of Voltage)

The tables below detail the instrument accuracy for the elements associated with the Division I Primary Undervoltage (LOV) Relays.

Loss of Voltage UV Relay 211R4175, 27D Standard Case (Ref. 8.2.5)
Div I - XY-27A/64B, YZ-27A/64B, XY-27A/64C, YZ-27A/64C
Div I - XN-27C/64B, YN-27C/64B, XN-27C/64C, YN-27C/64C

The existing calibration procedures (Ref. 8.2.7 through 8.2.10) include an ALT of ± 0.5 V. Per normal engineering practice and C1-4180 (Ref. 8.2.1) the ALT is normally set equal to VA. By output of this calculation, the calibration procedures will be revised to set ALT = VA, and to include a new as-found tolerance. Per Section 3.1.2, the as-found tolerance is based on the APT from Ref. 8.2.1. As a maximum, it will be set to the SRSS of the repeatability and drift, and will be reduced as needed to stay within the AVs. A smaller as-found tolerance is conservative, because it will provide earlier indication of degraded performance.

Relay Errors and Tolerances	**In 120V:**	**Units**	**σ**	**Source**
Errors in % of setting are taken at 120V to bound all possible settings				
VA = Repeatability = 0.2 V	0.2	V	2	8.1.2
PSE = Control Pwr Effect = 0.2 V per 10V change in control voltage. Taken over 105 to 138.5 V: PSE = (138.5 – 105V) * 0.2V / 10V	0.67	V	2	8.1.2 8.1.13
ATEN = Accuracy Temp Effect – Normal = 0.5V from 20-40 °C ATEN = (0.5 V)*(40 – 20)°C / (40 – 20)°C	0.5	V	2	8.1.2
ATEK = Accuracy Temp Effect - LOCA = 0.5V from 20-40 C, extend to to 49°C: ATEK = (0.5 V)*(49 – 20)°C / (40 – 20)°C	0.725	V	2	8.1.2 8.1.5
ALT = VA (new, see above)	0.2	V	3	–
As-Found Tolerance = APT = SQRT(VA^2 + LD^2)	0.6	V		–
Potential Transformers				
Accuracy Class 0.3% [3 σ], for max burden use 1.2%	1.2	%	3	8.2.2
PEA = (1.2%*120)*2/3	**0.96**	V	2	–
Relay Voltage Calibration Error Calculation (Equations per C1-4180, Ref. 8.2.1)				
CX = SQRT(CLI^2 + CLO^2) = CLI	0.108	V	3	App. H
EP = ALT if ALT> CX, otherwise EP = CX if ALT < CX	**0.2**	V	3	–
CC = (2/3)*SQRT((5/4)*CX^2 + EP^2)	0.15575	V	2	–
LC = SQRT(CC_1^2 + CC_2^2+ … + CCn^2) = CC	**0.15575**	V	2	–
Relay Voltage Error Calculation (Equations per C1-4180, Ref. 8.2.1)				
AN = 2*SQRT((VA/σ_{VA})^2 + (ATEN/σ_{ATEN})^2 + (PSE/σ_{PSE})^2)	**0.85959**	V	2	–
LAN = AN	**0.85959**	V	2	–
AK = 2*SQRT((VA/σ_{VA})^2 + (ATEK/σ_{ATEK})^2 + (PSE/σ_{PSE})^2)	1.00724	V	2	–
LAK = AK	**1.00724**	V	2	–
LD = 0.5%*Setpoint = 0.5%*120V	**0.6**	V	2	5.2

Voltage Channel Error Calculation (Equations per C1-4180, Ref. 8.2.1)				In 4160 V
EAV = (1.645/2)*SQRT(LAK^2 + LC^2 + PEA^2)	**1.15161**	**V**	1.645	**40.306**
CIEK = (1.645/2)*SQRT(LAK^2 + LC^2 + LD^2 + PEA^2)	**1.25290**	**V**	1.645	**43.852**
σLER = 0.5*SQRT(LAN^2 + LC^2 + LD^2)	**0.53**	**V**	1	**18.546**

Note: All error values are ±

The table below details the analysis for the Division I Loss of Voltage UV relay voltage AVs. Per the DECO File C1-4180 (Ref. 8.2.1) methodology the Technical Specification AVs are specified for a decreasing voltage setpoint, so the existing lower AV (AVL) is analyzed for acceptability using the standard formulas for a descending process as stated in Section 3.1. The existing AVL is used to determine a maximum lower analytical limit. This computed lower analytical limit is then used to compute a minimum relay actuation voltage using the standard formula from Section 3.1. The acceptability of the existing AVL and NTSP is then verified by subtracting all the possible sources of error from the existing NTSP and verifying that the result is equal to or greater than the minimum relay actuation voltage based on the computed lower Alim. Although this is a descending process trip, because there is no particular requirement for the upper ALim, the existing upper AV (AVU) is analyzed for acceptability by applying the same process described above for an ascending process trip. The minimum upper ALim is determined by adding the combination of the non-drift errors to the existing AVU. The existing NTSP and upper AV are acceptable if the upper ALim minus the combination of all errors including drift is shown to be greater than the existing NTSP.

The basic calculation is done in the 4160V bus voltage values. The 4160V values are converted to the 120V relay values by multiplying by the ratios from Section 3.3, which are 120/4200 for the P-P relay and 120/(√3 * 2400) for the P-N relay.

Division I Loss of Voltage Relays – Voltage	**4160 V:**	**% of 4160 V**	**At P-P Relay**	**At P-N Relay**	**Source**
Implied Minimum Upper ALim = AVU + EAV	**3134.0**	**75.3**			–
Existing AVU	**3093.7**	**74.4**	88.39	89.31	8.1.9
Existing Reset (increasing) 3% above SP (Reset = SP/0.97)	**3126.8**	**75.2**	89.34	90.26	8.1.2
Max NTSP ≤ AL - CIEK	3090.2	**74.3**			–
Max Possible actuation of existing NTSP = (NTSP + CIEK)	3076.9	**74.0**			–
NTSP + APT			87.26	88.16	–
NTSP + ALT			86.86	87.76	–
Existing NTSP (decreasing)	**3033.0**	**72.9**	86.66	87.56	8.1.7
NTSP - ALT			86.46	87.36	–
NTSP - APT			86.06	86.96	–
Min Possible actuation of existing NTSP = (NTSP – CIEK)	2989.1	**71.9**			–
Min NTSP ≥ AL + CIEK	2975.8	**71.5**			–
Existing AVL	**2972.3**	**71.4**	84.92	85.80	8.1.9
Implied Maximum Lower ALim = AVL - EAV	2932.0	**70.5**			–

Applying the LER avoidance test (Section 3.1.1), with σ_{LER} = 18.546 V (from Voltage Channel Error Calculation, this section)

$Z_{LER} = (|AVL - NTSP|)/\sigma_{LER} = (|2972.3 - 3033.0|)/18.546 = 3.27$ **PASS**

$Z_{LER} \geq 1.29$, so there is a greater than 90% probability of avoiding the AV

The NTSP plus and minus the APT is within the AVs, so the APT of 0.6 will be used as the as-found value.

The table below details the instrument accuracy for the elements associated with the Division I Primary Undervoltage (LOV) Relay Time Delay Settings. Since no drift value is provided for these relays, an assumed loop drift of 0.5% of setpoint is used in the calculation of total error.

Division I Loss of Voltage Time Delay Error and Tolerance	**Value**	**Units**	**σ**	**Source**
Errors in % of setting are taken at the 2 second setpoint				
Existing Setpoint	2.0	sec		8.1.7
VA = 10%, at 2 sec = 0.2 sec	0.200	sec	2	8.1.2
ALT = 0.05 sec	0.050	sec	3	8.2.7-8.2.10
As-Found Tolerance = APT = SQRT(VA^2 + LD^2)	0.200	sec		–
Relay Time Calibration Error Calculation (Equations per C1-4180, Ref. 8.2.1)				
CX = SQRT(CLI^2 + CLO^2) = CLI	0.00068	sec	3	App. H
EP = ALT if ALT> CX, otherwise EP = CX if ALT < CX	**0.050**	sec	3	–
CC = (2/3)*SQRT(2*CX^2 + EP^2)	0.03334	sec	2	–
LC = SQRT(CC_1^2 + CC_2^2+ … + CCn^2) = CC	**0.03334**	sec	2	–
Relay Time Error Calculation (Equations per C1-4180, Ref. 8.2.1)				
AK = 2*(VA/σ_{VA}) = AN **	0.200	sec	2	–
LAK= AK = LAN **	**0.200**	sec	2	–
LD = 0.5%*Setpoint = 0.005*2	**0.010**	sec	2	5.2
Time Channel Error Calculation (Equations per C1-4180, Ref. 8.2.1)				
EAV = (1.645/2)*SQRT(LAK^2 + LC^2)	**0.1668**	sec	1.645	–
CIEK =(1.645/2)*SQRT(LAK^2 + LC^2 + LD^2)	**0.1670**	sec	1.645	–
σLER = 0.5*SQRT(LAN^2 + LC^2 + LD^2)	**0.1015**	sec	1	–

Note: All error values are ±

** The manufacturer does not specify an accuracy temperature effect for the time delay actuation. Thus the normal and post-accident accuracies are the same, so AN = AK and LAN = LAK.

The existing Technical Specification AVs and the existing NTSP for the loss of voltage UV relay actuation times are analyzed for acceptability by applying the standard methodology from DECO File C1-4180 (Ref. 8.2.1) to determine implied upper and lower analytical limits based on the relay operation error. The implied upper and lower analytical limits are then used to calculate minimum and maximum NTSPs for an ascending process as stated in Section 3.1. The existing AVs and NTSPs are acceptable if the existing AVs bound the minimum and maximum setpoints calculated as described above.

Division I Loss of Voltage Relays - Time	**Value**	**Units**	**Source**
Min Upper ALim Implied by existing AVU: ALim ≥ AVU + EAV	2.267	sec	–
Max Possible setpoint actuation w/ existing NTSP: NTSP + CIEK	2.167	sec	–
Existing Tech Spec AVU	**2.100**	sec	8.1.9
NTSP + APT > AVU, so reduce APT to 0.1 sec	2.200	sec	–
NTSP + reduced APT	**2.100**	**sec**	**–**
NTSP + ALT	2.050	**sec**	–
Existing NTSP (increasing)	**2.000**	**sec**	8.2.7-8.2.10
NTSP – ALT	1.950	sec	–
NTSP – reduced APT	**1.900**	**sec**	**–**
NTSP – APT < AVL, so reduce APT to 0.1 sec	1.800	sec	–
Existing Tech Spec AVL	**1.900**	sec	8.1.9
Min Possible setpoint actuation w/ existing NTSP: NTSP - CIEK	1.833	sec	–
Max Lower ALim Implied by existing AVL: ALim ≤ AVL - EAV	1.733	sec	–

The existing relay time setpoint is bounded by the upper and lower Allowable Values in the Technical Specifications. The existing nominal trip setpoint and Allowable Values support the Analytical Limits shown.

The as-found value (or APT) is set at ± 0.10 seconds to remain within the AVs.

Applying the LER avoidance test (Section 3.1.1), with $\sigma_{LER} = 0.1015$ sec (from Time Channel Error Calculation, this section)

$$Z_{LER} = (|\text{AVU} - \text{NTSP}|)/\sigma_{LER} = (|2.100 - 2.000|)/0.1015 = 0.99$$

For a single channel, Z_{LER} must be ≥ 1.29 to pass. The loss of voltage relays are arranged in one-out-of-two-taken-twice logic (Ref. 8.2.40 – 8.2.43). Thus the actuation of more than one relay is required (multiple channels), and the multiple channel LER avoidance limit is applied. From C1-4180 (Ref. 8.2.1), for multiple channels, there is a 90% probability of avoiding the LER if $Z_{LER} > 0.81$. In this case:

$Z_{LER} = 0.99 \geq 0.81$ **PASS**

Because multiple channels are required, and the Z_{LER} is ≥ 0.81, there is a greater than a 90% probability that the LER will be avoided.

9.1.2 Division I Reactor Building 4160V Secondary Undervoltage (Degraded Voltage) Relay

The table below details the instrument accuracy for the elements associated with the Division I Secondary Undervoltage (Degraded Voltage) Relays.

Degraded Voltage Relay 211T4175-HF-1E, 27N Standard Case (Ref. 8.2.5)
Div I - XY-27B/64B, YZ-27B/64B, XY-27B/64C, YZ-27B/64C
Div I - YN-27D/64B, ZN-27D/64B, YN-27D/64C, ZN-27D/64C

The existing calibration procedures (Ref. 8.2.7 through 8.2.10) include an ALT of ± 0.5 V. Per normal engineering practice and C1-4180 (Ref. 8.2.1) the ALT is normally set equal to VA. By output of this calculation, the calibration procedures will be revised to set ALT = VA, and to include a new as-found tolerance. Per Section 3.1.2, the as-found tolerance is based on the APT from Ref. 8.2.1. As a maximum, it will be set to the SRSS of the repeatability and drift, and will be reduced as needed to stay within the AVs. A smaller as-found tolerance is conservative, because it will provide earlier indication of degraded performance.

Relay Errors and Tolerances	**In 120V:**	**Units**	**σ**	**Source**
Errors in % of setting are taken at 120V to bound all possible settings				
VA = Repeatability = 0.10%*120 =0.12 V	0.12	V	2	8.1.3
PSE = Control Pwr Effect = 0.10%*120V (from 100 to 140 Vdc)	0.12	V	2	8.1.3
ATEN = Accuracy Temp Effect – Normal = 0.4%*120 (from 10 to 40°C), taken over 20-40°C: ATEN = (0.4%*120 V)*(40 – 20)°C / (40 – 10)°C	0.320	V	2	8.1.3
ATEK = Accuracy Temp Effect – LOCA = 0.75%*120 (from 0 to 55C), taken over 20-49C: ATEK = (0.75%*120 V)*(49 – 20)°C / (55 – 0)°C	0.475	V	2	8.1.3 8.1.5
ALT = VA (new – see above)	0.12	V	3	–
As-Found Tolerance = APT = SQRT(VA^2 + LD^2)	0.61	V		–
Potential Transformers				
Accuracy Class 0.3% [3 σ], for max burden use 1.2%	1.2	%	3	8.2.2
PEA = (1.2%*120)*2/3	**0.96**	V	2	–
Relay Voltage Calibration Error Calculation (Equations per C1-4180, Ref. 8.2.1)				
CX = SQRT(CLI^2 + CLO^2) = CLI	0.108	V	3	App. H
EP = ALT if ALT> CX, otherwise EP = CX if ALT < CX	**0.12**	V	3	–
CC = (2/3)*SQRT((5/4)*CX^2 + EP^2)	0.11349	V	2	–
LC = SQRT(CC_1^2 + CC_2^2+ … + CCn^2) = CC	**0.11349**	V	2	–
Relay Voltage Error Calculation (Equations per C1-4180, Ref. 8.2.1)				
AN = 2*SQRT((VA/σ_{VA})^2 + (ATEN/σ_{ATEN})^2 + (PSE/σ_{PSE})^2)	0.36222	V	2	–
LAN = AN	**0.36222**	V	2	–
AK = 2*SQRT((VA/σ_{VA})^2 + (ATEK/σ_{ATEK})^2 + (PSE/σ_{PSE})^2)	0.50441	V	2	–
LAK = AK	**0.50441**	V	2	–
LD = 0.5%*Setpoint = 0.5%*120V	0.6	V	2	5.2

Voltage Channel Error Calculation (Equations per C1-4180, Ref. 8.2.1)				in 4160 V
EAV = (1.645/2)*SQRT(LAK^2 + LC^2 + PEA^2)	**0.89683**	V	1.645	**31.389**
CIEK = (1.645/2)*SQRT(LAK^2 + LC^2 + LD^2 + PEA^2)	**1.02364**	V	1.645	**35.827**
σLER = 0.5*SQRT(LAN^2 + LC^2 + LD^2)	**0.35499**	**V**	1	**12.425**

Note: All error values are ±

The table below determines new AVs and NTSPs for the degraded voltage UV relay voltages based on the new ALims provided by reference 8.2.14. Because the Technical Specification AVs are for a decreasing voltage setpoint, the lower AV (AVL) is determined via the standard formula for a descending process as stated in Section 3.1. The upper AV (AVU) is then determined by adding the maximum channel error to the operate NTSP. This will set the AVU at the maximum point at which the decreasing voltage can actuate the relay once all the possible sources of error have been considered. The maximum Reset point is determined by dividing the AVU (max possible actuation point) by 0.995 based on the desired 0.5% differential between operate and reset voltages. This maximum possible reset point must be ≤ the Upper Analytical Limit, which is the upper voltage determined in the voltage analysis, (Reference 8.2.14).

Division I Secondary Undervoltage (Degraded Voltage) Voltage Settings – Initial NTSP

Division I Degraded Voltage Relays - Voltage	**4160 V**	**% of 4160 V**	**At P-P Relay**	**At P-N Relay**	**Source**
New Upper ALim	3972.8	95.5			8.1.10
New Max Reset = max SP/0.995	**3964.6**	**95.3**			–
New AVU = NTSP + CIEK	**3944.8**	**94.8**	112.71	113.88	–
New Reset = NTSP/0.995	3928.6	94.4	112.25	113.41	–
New NTSP (decreasing) rounded up from minimum	**3909.0**	**94.0**	111.69	112.84	–
Min NTSP ≥ ALim + CIEK	3908.8	94.0			–
New AVL: AVL ≥ ALim + EAV	**3904.4**	93.9	111.55	112.71	–
New Lower ALim	3873.0	**93.1**			8.1.10
Existing Tech Spec AVU	4031.0				8.1.9
Existing NTSP (decreasing)	3952.0				8.1.7
Existing Tech Spec AVL	3873.0				8.1.9

Applying the LER avoidance test (Section 3.1.1), with σ_{LER} = 12.425 V (from Voltage Channel Error Calculation, this section)

$Z_{LER} = (|\text{AVL} - \text{NTSP}|)/\sigma_{LER} = (|3904.4 - 3909.0|)/12.425 = 0.37$ **FAIL**

Z_{LER} is much less than 1.29, so there is much less than a 90% probability of avoiding violation of the AV

The NTSP will be moved higher, but still within the upper and lower AVs, to provide more margin between the NTSP and the lower AV and ALim for this decreasing voltage trip. The NTSP will be moved to a point halfway between the two AVs.

	4160 V	% of 4160 V	At P-P Relay	At P-N Relay
AVU (from above)	3944.8	94.8	112.71	113.88
AVL (from above)	3904.4	93.9	111.55	112.71
New NTSP (centered between AVL and AVU)	**3924.6**	**94.3**	**112.13**	**113.29**
NTSP reset = NTSP/0.995	**3944.3**	**94.8**	**112.69**	**113.86**

Again applying the LER avoidance test:

$Z_{LER} = (|\text{AVL - NTSP}|)/\sigma_{LER} = (|3904.4 - 3924.6|)/12.425 = 1.63$ **PASS**

Z_{LER} is ≥ 1.29, so there is greater than a 90% probability of avoiding violation of the AV

The new settings, including ALT and APT, taken around the adjusted NTSP:

Division I Secondary Undervoltage (Degraded Voltage) Voltage Settings – Recommended NTSP

Division I Degraded Voltage Relays - Voltage	4160 V	% of 4160 V	At P-P Relay	At P-N Relay	Source
New Upper ALim	3972.8	95.5			8.1.10
New Max Reset = max SP/0.995	**3964.6**	**95.3**			–
New AVU = NTSP + CIEK	**3944.8**	**94.8**	112.71	113.88	–
Reset + reduced APT			113.27	114.44	–
Reset + ALT			112.81	113.98	–
New Reset = NTSP/0.995	**3944.3**	**94.8**	112.69	113.86	–
Reset - ALT			112.57	113.74	–
Reset – reduced APT			112.11	113.28	–
NTSP + APT > AVU, so reduce APT to 0.58			112.74	113.90	–
NTSP + reduced APT			112.71	113.87	–
NTSP + ALT			112.25	113.41	–
New NTSP (decreasing) rounded up from minimum	**3924.6**	**94.3**	112.13	113.29	–
NTSP – ALT			112.01	113.17	–
NTSP – reduced APT			111.55	112.71	–
NTSP – APT < AVL, so reduce APT to 0.58			111.52	112.68	–
Min NTSP ≥ ALim + CIEK	3908.8	94.0			–
New AVL: AVL ≥ ALim + EAV	**3904.4**	93.9	111.55	112.71	–
New Lower ALim	3873.0	**93.1**			8.1.10

The as-found value (or APT) is set at ± 0.58 volts to remain within the AVs.

Bus Low Voltage Alarm

The bus low voltage alarm shall be set at a voltage greater than the degraded undervoltage relay maximum set value and below the lower end of the transformer 64 LTC voltage regulator control band. Additional time delay (20 seconds) shall be included so the load tap changer can automatically adjust for voltage fluctuations. The total time delay for the alarm shall be 30 seconds (Ref. 8.2.29).

Alarm Setpoint: 4076.8 V (98.0% on 4160V base)
Time Delay: 30 sec.

9.1.3 Div. I Secondary UV (Degraded Voltage) Time Delay

The table below details the instrument accuracy for the elements associated with the Division I LOCA Time Delay Relays

Division I LOCA Time Delay

Degraded Voltage Relay 211T4175-HF-1E, 27N Standard Case (Ref. 8.2.5)
Div I – XY-27B/64B, YZ-27B/64B, XY-27B/64C, YZ-27B/64C
Div I – YN-27D/64B, ZN-27D/64B, YN-27D/64C, ZN-27D/64C

For conservatism, those errors that are based on % of setting will use a setting that is larger than the actual setpoint. A setting of 7.31 seconds is chosen for this purpose. It is an acceptable, conservative value because it is larger than the setpoint plus the ALT (7.20 seconds, on next page).

Time Delay Error and Tolerance	**Value**	**Units**	**σ**	**Source**
Maximum setting to use with % setting errors – see above	7.31	sec		–
VA = greater of 20 mS or 10% of setting	0.73	sec	2	8.1.3
ALT = increase to 0.5 sec – see below	0.500	sec	3	–
As-Found Tolerance = APT = SQRT(VA^2 + LD^2)	0.73	sec		–
Relay Time Calibration Error Calculation (Equations per C1-4180, Ref. 8.2.1)				
CX = SQRT(CLI^2 + CLO^2) = CLI	0.00068	sec	3	App. H
EP = ALT if ALT> CX, otherwise EP = CX if ALT < CX	**0.500**	sec	3	–
CC = (2/3)*SQRT(2*CX^2 + EP^2)	0.33333		2	–
LC = SQRT(CC_1^2 + CC_2^2+ … + CCn^2) = CC	**0.33333**	sec	2	–
Relay Time Error Calculation (Equations per C1-4180, Ref. 8.2.1)				
AK = 2*(VA/σ_{VA}) = AN **	0.731	sec	2	–
LAK= AK = LAN **	**0.731**	sec	2	–
LD = 0.5%*setting	**0.037**	sec	2	5.2
Time Channel Error Calculation (Equations per C1-4180, Ref. 8.2.1)				
EAV = (1.645/2)*SQRT(LAK^2 + LC^2)	**0.6608**	sec	1.645	–
CIEK = (1.645/2)*SQRT(LAK^2 + LC^2 + LD^2)	**0.6615**	sec	1.645	–
σLER = 0.5*SQRT(LAN^2 + LC^2 + LD^2)	**0.4021**	sec	1	–

All error values are ±.

** The manufacturer does not specify an accuracy temperature effect for the time delay actuation. Thus the normal and post-accident accuracies are the same, so AN = AK and LAN = LAK.

Calibration ALT is increased from existing ±0.05 seconds to ±0.5 seconds. Good practice is to set the ALT equal to the VA when possible, or to use at least one half of the VA. Since the VA is ±0.731 seconds, the existing ±0.05 seconds is an order of magnitude too small. Thus it is increased in this analysis to a more realistically achievable ±0.5 seconds, and by output of this calculation will be changed in the calibration procedure.

Per Section 3.1.2, the as-found tolerance is based on the APT from Ref. 8.2.1. As a maximum, it will be set to the SRSS of the repeatability and drift, and will be reduced as needed to stay within the AVs. A smaller as-found tolerance is conservative, because it will provide earlier indication of degraded performance.

The upper Alim for the LOCA time delay supports the 13 second EDG start time from the LOCA analysis (Ref. 8.2.19, UFSAR Tables 6.3-7 & 8.3-5). The EDG start circuit includes a separate time delay relay, and an additional 0.18 seconds is required to account for the closure times of the EDG output and RHR pump motor breakers. Thus the upper ALim for the DV LOCA time delay is determined by subtracting the maximum EDG start timer delay and 0.18 seconds from the 13 second EDG start time for LOCA. Appendix G contains the determination of error associated with the EDG start timer relay.

The Technical Specification AVs for the LOCA condition degraded voltage relays are for an increasing time setpoint, so a new upper AV (AVU) is calculated via the standard formula for an ascending process as stated in Section 3.1. The lower ALim is conservatively chosen as 5.50 seconds to be greater than the Core Spray pump acceleration time (Ref. 8.2.14). The new lower AV (AVL) for LOCA conditions is calculated via the standard formula for a descending process as stated in Section 3.1. The new NTSP is calculated as the average of the upper and lower ALims rounded to the nearest 0.1 second.

Division I DV Relay LOCA Time Delay	**Value**	**Units**	**Source**
Upper ALim (13 sec DG Start – DG timer relay max time)	7.97	sec	App. G
New Tech Spec AVU = ALim – EAV	**7.31**	**sec**	–
Max SetPt = ALim – CIEK	7.31	sec	–
NTSP + APT > AVU, so reduce APT to 0.54 sec	7.43	sec	–
NTSP + reduced APT	**7.24**	sec	–
Setpt + ALT	7.20	sec	–
New NTSP (increasing) = Average of ALims, rounded to 1 digit	**6.7**	**sec**	–
Setpt – ALT	6.20	sec	–
NTSP – reduced APT	**6.16**	sec	–
NTSP – APT < AVL, so reduce APT to 0.54 sec	5.97	sec	–
Min SetPt = ALim + CIEK	6.16	sec	–
New Tech Spec AVL = ALim + EAV	**6.16**	**sec**	–
Lower ALim	5.50	sec	8.1.12
Average of ALims: New NTSP to be set in the center of the range.			

Inspection of these values shows that the setpoint is within the range of maximum and minimum setpoint values with respect to the upper and lower ALims and so is acceptable. The new AVs are separated from their respective ALims by the required uncertainties.

Applying the LER avoidance test (Section 3.1.1), with σ_{LER} = 0.4021 sec (from Time Channel Error Calculation, this section)

$Z_{LER} = (|\text{AVU - NTSP}|)/\sigma_{LER} = (|7.31 - 6.7|)/0.4021 = 1.52$ **PASS**

$Z_{LER} \geq 1.29$, so there is a greater than 90% probability of avoiding violation of the AV

The as-found value (or APT) is set at ± 0.54 seconds to remain within the AVs.

The table below details the instrument accuracy for the elements associated with the Division I Non-LOCA Time Delay Relays. Since no drift value is provided for these relays, an assumed loop drift of 0.5% of setpoint is used in the calculation of total error.

Degraded Voltage Non-LOCA Timer Relays Agastat E7012PD (Ref. 8.2.5)
Div I Bus 64B: 1RU62 and Div I Bus 64C: 1RV62

For conservatism, those errors that are based on % of setting will use a setting that is larger than the actual setpoint. A setting of 38.3 seconds is chosen for this purpose. It is an acceptable, conservative value because it is equal to the NTSP plus the ALT (on next page).

Non- LOCA Div. I Time Delay Error and Tolerance	**Agastat Only**	**Units**	**σ**	**Source**
Agastat setting to use with % setting errors (see above)	38.3	sec		–
VA = 5% of setting	1.915	sec	3	8.1.4
ALT = 1 sec	1.000	sec	3	8.2.7 – 8.2.10
As-Found Tolerance = APT = SQRT(VA^2 + LD^2)	1.92	sec		–
Relay Time Calibration Error Calculation (Equations per C1-4180, Ref. 8.2.1)				
CX = SQRT(CLI^2 + CLO^2) = CLI	0.00375	sec	3	App. H
EP = ALT if ALT> CX, otherwise EP = CX if ALT < CX	**1.000**	sec	3	–
CC = (2/3)*SQRT(2*CX^2 + EP^2)	0.66668	sec	2	–
LC = SQRT(CC_1^2 + CC_2^2+ … + CCn^2) = CC	**0.66668**	sec	2	–
Relay Time Error Calculation (Equations per C1-4180, Ref. 8.2.1)				
AK = 2*(VA/σ_{VA}) = AN **	1.277	sec	2	–
LAK= AK = LAN **	**1.277**	sec	2	–
LD = 0.5%*Setting	**0.192**	sec	2	5.2
Time Channel Error Calculation (Equations per C1-4180, Ref. 8.2.1)				
EAV = (1.645/2)*SQRT(LAK^2 + LC^2)	**1.1849**	sec	1.645	–
CIEK = (1.645/2)*SQRT(LAK^2 + LC^2 + LD^2)	**1.1953**	sec	1.645	–
σLER = 0.5*SQRT(LAN^2 + LC^2 + LD^2)	**0.7266**	sec	1	–

Note: All errors are ±.

** The manufacturer does not specify an accuracy temperature effect for the time delay actuation. Thus the normal and post-accident accuracies are the same, so AN = AK and LAN = LAK.

For non-LOCA conditions, the output of the ABB undervoltage relay (set at the LOCA time delay) starts a second Agastat timer relay. Thus the total non-LOCA time delay is the combination of the time delay from the degraded voltage undervoltage ABB relay (set at the LOCA time delay) and the time delay of the Agastat timer relay. The Technical Specification non-LOCA time AVs must be shown to bound the combination of the individual time AVs for the undervoltage relay LOCA time plus the non-LOCA timer relay (Agastat) time. The total NTSP for the non-LOCA time operate point is the undervoltage relay LOCA time NTSP plus the NTSP of the timer relay.

Division I Non–LOCA Time Delay Agastat Settings

Division I Degraded Voltage Non-LOCA Timer Relay (Agastat)	Total Time	Time at Agastat	Units	Source
Min Total Upper ALim (add 3.5 sec) for max EDG start	51.546		sec	–
Min Upper ALim Implied by existing AVU: ALim ≥ AVU + EAV	48.046		sec	–
Agastat portion of Min Upper ALim: $ALim_{AG} \geq AVU_{AG}$ + EAV		40.076	sec	–
Existing Tech Spec AVU	**46.2**		sec	8.1.9
Agastat portion of AVU: AVU – AVU_{LOCA}		38.891	sec	–
Max Possible setpoint actuation w/ existing NTSP: NTSP + CIEK		38.495	sec	–
Max NTSP for Upper ALim: Max NTSP ≤ ALim – CIEK		37.516	sec	–
NTSP + APT > AVU, so reduce APT to 1.59 sec		39.220	sec	–
NTSP + reduced APT		**38.890**	sec	–
Setpt + ALT		38.300	sec	–
Existing NTSP (increasing)	**44.000**		sec	8.1.7
Agastat NTSP: Total NTSP – $NTSP_{LOCA}$		**37.300**	sec	–
Setpt – ALT		36.300	sec	–
NTSP – reduced APT		**35.710**	sec	–
NTSP – APT < AVL, so reduce APT to 1.59 sec		35.380	sec	–
Min Possible setpoint actuation w/ existing NTSP: NTSP – CIEK		36.105	sec	–
Min NTSP for Lower ALim: Min NTSP ≥ ALim + CIEK		35.650	sec	–
Existing Tech Spec AVL	**41.8**			8.1.9
Agastat portion of AVL_{AG}: AVL – AVL_{LOCA}		35.640	sec	–
Max Lower ALim Implied by existing AVL: ALim ≤ AVL –EAV	39.995		sec	–
Agastat portion of Max Lower ALim: $ALim_{AG} \leq AVL_{AG}$ – EAV		34.455	sec	–

Applying the LER avoidance test (Section 3.1.1), with σ_{LER} = 0.7266 sec (from Time Channel Error Calculation, this section)

Z_{LER} = (| AVU - NTSP |)/σ_{LER} = (|38.891 - 37.300 |)/0.7266 = 2.19 **PASS**

$Z_{LER} \geq 1.29$, so there is a greater than 90% probability of avoiding violation of the AV

The as-found value (or APT) is set at ± 1.59 seconds to remain within the AVs.

9.1.4 480V Primary Undervoltage

The 480V bus primary UV devices should coordinate with the 4160V primary device. Loss of voltage at the 4160V buses initiates the EDG's. The 4160V buses should trip first to prevent isolation of a 480V bus without EDG initiation. There is typically a 2-3% voltage drop between the 480 and 4160V buses. To assure selectivity, all 480 UV relays are set at 43% (206.4 V) with a 2 second minimum inverse time delay.

Trip Setpoint: 206.4 V
Time Delay: 2 sec

9.2 Setpoint Determination and Acceptance Criteria for Division I RHR Building

9.2.1 4160 Primary Undervoltage

All RHR 4160V UV relays are set at 2247V (54%) with a 2 second minimum inverse time delay.

Trip Setpoint: 2247V
Time Delay: 2 sec.

9.2.2 480V Primary Undervoltage

The 480V bus primary UV devices should coordinate with the 4160V primary device. Loss of voltage at the 4160V buses initiates the EDG's. The 4160V buses should trip first to prevent isolation of a 480V bus without EDG initiation. There is typically a 2-3% voltage drop between the 480 and 4160V buses. To assure selectivity, all 480 UV relays are set at 43% (206.4 V) with a 2 second minimum inverse time delay.

Trip Setpoint: 206.4 V
Time Delay: 2 sec.

9.3 Setpoint Determination and Acceptance Criteria for Division II Reactor Building

9.3.1 Div II Reactor Building 4160V Primary Undervoltage (Loss of Voltage)

The tables below detail the instrument accuracy for the elements associated with the Division II Primary Undervoltage (LOV) Relays.

Loss of Voltage UV Relay 211R4175, 27D Standard Case (Ref. 8.2.5)
Div II – XY-27A/65E, YZ-27A/65E, XY-27A/65F, YZ-27A/65F
Div II – XN-27C/65E, YN-27C/65E, XN-27C/65F, YN-27C/65F

The existing calibration procedures (Ref. 8.2.7 through 8.2.10) include an ALT of ± 0.5 V. Per normal engineering practice and C1-4180 (Ref. 8.2.1) the ALT is normally set equal to VA. By output of this calculation, the calibration procedures will be revised to set ALT = VA, and to include a new as-found tolerance. Per Section 3.1.2, the as-found tolerance is based on the APT from Ref. 8.2.1. As a maximum, it will be set to the SRSS of the repeatability and drift, and will be reduced as needed to stay within the AVs. A smaller as-found tolerance is conservative, because it will provide earlier indication of degraded performance.

Relay Errors and Tolerances	**In 120V:**	**Units**	**σ**	**Source**
Errors in % of setting are taken at 120V to bound all possible settings				
VA = Repeatability = 0.2 V	0.2	V	2	8.1.2
PSE = Control Pwr Effect = 0.2 V per 10V change in control voltage. Taken over 105 to 138.5 V: PSE = (138.5 – 105V) * 0.2V / 10V	0.67	V	2	8.1.2 8.1.13
ATEN = Accuracy Temp Effect – Normal = 0.5V from 20-40 °C ATEN = (0.5 V)*(40 – 20)°C / (40 – 20)°C	0.5	V	2	8.1.2
ATEK = Accuracy Temp Effect – LOCA = 0.5V from 20-40 °C, extend to 49 C: ATEK = (0.5 V)*(49 – 20)°C / (40 – 20)°C	0.725	V	2	8.1.2 8.1.5
ALT = VA (new – see above)	0.2	V	3	–
As-Found Tolerance = APT = SQRT(VA^2 + LD^2)	0.6	V		–
Potential Transformers				
Accuracy Class 0.3% [3 σ], for max burden use 1.2%	1.2	%	3	8.2.2
PEA = (1.2%*120/100)*2/3	**0.96**	V	2	–
Relay Voltage Calibration Error Calculation (Equations per C1-4180, Ref. 8.2.1)				
CX = SQRT(CLI^2 + CLO^2) = CLI	0.108	V	3	App. H
EP = ALT if ALT> CX, otherwise EP = CX if ALT < CX	**0.2**	V	3	–
CC = (2/3)*SQRT((5/4)*CX^2 + EP^2)	0.15575	V	2	–
LC = SQRT(CC_1^2 + CC_2^2+ … + CCn^2) = CC	**0.15575**	V	2	–
Relay Voltage Error Calculation (Equations per C1-4180, Ref. 8.2.1)				
AN = 2*SQRT((VA/σ_{VA})^2 + (ATEN/σ_{ATEN})^2 + (PSE/σ_{PSE})^2)	**0.85959**	V	2	–
LAN = AN	**0.85959**	V	2	–
AK = 2*SQRT((VA/σ_{VA})^2 + (ATEK/σ_{ATEK})^2 + (PSE/σ_{PSE})^2)	1.00724	V	2	–
LAK = AK	**1.00724**	V	2	–
LD = 0.5%*Setpoint = 0.5%*120V	**0.6**	V	2	5.2

Voltage Channel Error Calculation (Equations per C1-4180, Ref. 8.2.1)				In 4160 V
EAV = (1.645/2)*SQRT(LAK^2 + LC^2 + PEA^2)	**1.15161**	**V**	1.645	**40.306**
CIEK = (1.645/2)*SQRT(LAK^2 + LC^2 + LD^2 + PEA^2)	**1.25290**	**V**	1.645	**43.852**
σLER = 0.5*SQRT(LAN^2 + LC^2 + LD^2)	**0.53**	**V**	1	**18.55**

Note: All error values are ±

The table below details the analysis for the Division I Loss of Voltage UV relay voltage AVs. Per the DECO File C1-4180 (Ref. 8.2.1) methodology the Technical Specification AVs are specified for a decreasing voltage setpoint, so the existing lower AV (AVL) is analyzed for acceptability using the standard formulas for a descending process as stated in Section 3.1. The existing AVL is used to determine a maximum lower analytical limit. This computed lower analytical limit is then used to compute a minimum relay actuation voltage using the standard formula from Section 3.1. The acceptability of the existing AVL and NTSP is then verified by subtracting all the possible sources of error from the existing NTSP and verifying that the result is equal to or greater than the minimum relay actuation voltage based on the computed lower Alim. Although this is a descending process trip, because there is no particular requirement for the upper ALim, the existing upper AV (AVU) is analyzed for acceptability by applying the same process described above for an ascending process trip. The minimum upper ALim is determined by adding the combination of the non-drift errors to the existing AVU. The existing NTSP and upper AV are acceptable if the upper ALim minus the combination of all errors including drift is shown to be greater than the existing NTSP.

The basic calculation is done in the 4160V bus voltage values. The 4160V values are converted to the 120V relay values by multiplying by the ratios from Section 3.3, which are 120/4200 for the P-P relay and 120/(√3 * 2400) for the P-N relay.

Division II Loss of Voltage Relay – Voltage	**4160 V:**	**% of 4160 V**	**At P-P Relay**	**At P-N Relay**	**Source**
Implied Minimum Upper ALim = AVU + EAV	**3179.9**	**76.4**			–
Existing AVU	**3139.6**	**75.5**	89.70	90.63	8.1.9
Existing Reset (increasing) 3% above SP (Reset = SP/0.97)	**3173.2**	**76.3**	90.66	91.60	8.1.2
Max NTSP ≤ ALim – CIEK	3136.1	**75.4**			–
Max Possible actuation of existing NTSP = (NTSP + CIEK)	3121.9	**75.0**			–
NTSP + APT			88.54	89.45	–
NTSP + ALT			88.14	89.05	–
Existing NTSP (decreasing)	**3078.0**	**74.0**	87.94	88.85	8.1.7
NTSP – ALT			87.74	88.65	–
NTSP - APT			87.34	88.25	–
Min Possible actuation of existing NTSP = (NTSP – CIEK)	3034.1	**72.9**			–
Min NTSP ≥ ALim + CIEK	3019.9	**72.6**			–
Existing AVL	**3016.4**	**72.5**	86.18	87.08	8.1.9
Implied Maximum Lower ALim = AVL – EAV	2976.1	**71.5**			–

Applying the LER avoidance test (Section 3.1.1), with σ_{LER} = 18.55 V (from Voltage Channel Error Calculation, this section)

Z_{LER} = (| AVL - NTSP |)/σ_{LER} = (| 3016.4 - 3078.0 |)/18.55 = 3.32 **PASS**

$Z_{LER} \geq 1.29$, so there is a greater than 90% probability of avoiding violation of the AV

The NTSP plus and minus the APT is within the AVs, so the APT will be used as the as-found value.

The table below details the instrument accuracy for the elements associated with the Division II Primary Undervoltage (LOV) Relay Time Delay Settings. Since no drift value is provided for these relays, an assumed loop drift of 0.5% of setpoint is used in the calculation of total error.

Division II Loss of Voltage Time Delay Error and Tolerance	**Value**	**Units**	**σ**	**Source**
Errors in % of setting are taken at the 2 second setpoint				
Existing Setpoint	2.0	sec		8.1.7
VA = 10%, at 2 sec = 0.2 sec	0.200	sec	2	8.1.2
ALT = 0.05 sec	0.050	sec	3	8.2.7-8.2.10
APT = SQRT(VA^2 + LD^2)	0.200	sec		–
Relay Time Calibration Error Calculation (Equations per C1-4180, Ref. 8.2.1)				
CX = SQRT(CLI^2 + CLO^2) = CLI	0.00068	sec	3	App. H
EP = ALT if ALT> CX, otherwise EP = CX if ALT < CX	**0.050**	sec	3	–
CC = (2/3)*SQRT(2*CX^2 + EP^2)	0.03334	sec	2	–
LC = SQRT(CC_1^2 + CC_2^2+ … + CCn^2) = CC	**0.03334**	sec	2	–
Relay Time Error Calculation (Equations per C1-4180, Ref. 8.2.1)				
AK = 2*(VA/σ_{VA}) = AN **	0.200	sec	2	–
LAK= AK = LAN **	**0.200**	sec	2	–
LD = 0.5%*Setpoint = 0.005*2	**0.010**	sec	2	5.2
Time Channel Error Calculation (Equations per C1-4180, Ref. 8.2.1)				
EAV = (1.645/2)*SQRT(LAK^2 + LC^2)	**0.1668**	sec	1.645	–
CIEK =(1.645/2)*SQRT(LAK^2 + LC^2 + LD^2)	**0.1670**	sec	1.645	–
σLER = 0.5*SQRT(LAN^2 + LC^2 + LD^2)	**0.1015**	sec	1	–

Note: All errors are ±.

** The manufacturer does not specify an accuracy temperature effect for the time delay actuation. Thus the normal and post-accident accuracies are the same, so AN = AK and LAN = LAK.

The existing Technical Specification AVs and the existing NTSP for the loss of voltage UV relay actuation times are analyzed for acceptability by applying the standard methodology from C1-4180 (Ref. 8.2.1) to determine implied upper and lower analytical limits based on the relay operation error. The implied upper and lower analytical limits are then used to calculate minimum and maximum NTSPs for an ascending process as stated in Section 3.1. The existing AVs and NTSPs are acceptable if the existing AVs bound the minimum and maximum setpoints calculated as described above.

Division II Loss of Voltage Relays – Time	**Value**	**Units**	**Source**
Min Upper ALim Implied by existing AVU: ALim ≥ AVU + EAV	2.267	sec	–
Max Possible setpoint actuation w/ existing NTSP: NTSP + CIEK	2.167	sec	–
Existing Tech Spec AVU	**2.100**	sec	8.1.9
NTSP + APT > AVU, so reduce APT to 0.1 sec	2.200	sec	–
NTSP + APT - reduced	**2.100**	**sec**	**–**
NTSP + ALT	2.050	**sec**	–
Existing NTSP (increasing)	**2.000**	**sec**	8.2.7-8.2.10
NTSP - ALT	1.950	sec	–
NTSP – APT - adjusted	**1.900**	**sec**	**–**
NTSP – APT < AVL, so reduce APT to 0.1 sec	1.800	sec	–
Existing Tech Spec AVL	**1.900**	sec	8.1.9
Min Possible setpoint actuation w/ existing NTSP: NTSP – CIEK	1.833	sec	–
Max Lower ALim Implied by existing AVL: ALim ≤ AVL – EAV	1.733	sec	–

The existing relay time setpoint is bounded by the upper and lower Allowable Values in the Technical Specifications. The existing nominal trip setpoint and Allowable Values support the Analytical Limits shown.

The as-found value (or APT) is set at ± 0.100 seconds to remain within the AVs.

Applying the LER avoidance test (Section 3.1.1), with σ_{LER} = 0.1015 sec (from Time Channel Error Calculation, this section)

$$Z_{LER} = (|\,AVU - NTSP|)/\sigma_{LER} = (|\,2.100 - 2.000\,|)/0.1015 = 0.99$$

For a single channel, Z_{LER} must be ≥ 1.29 to pass. The loss of voltage relays are arranged in one-out-of-two-taken-twice logic (Ref. 8.2.40 – 8.2.43). Thus the actuation of more than one relay is required (multiple channels), and the multiple channel LER avoidance limit is applied. From C1-4180 (Ref. 8.2.1), for multiple channels, there is a 90% probability of avoiding the LER if $Z_{LER} > 0.81$. In this case:

$Z_{LER} = 0.99 \geq 0.81$ **PASS**

Because multiple channels are required, and the Z_{LER} is ≥ 0.81, there is a greater than a 90% probability that the LER will be avoided.

9.3.2 - Division II Reactor Building 4160V Secondary Undervoltage (Degraded Voltage) Relay

The table below details the instrument accuracy for the elements associated with the Division II Secondary Undervoltage (Degraded Voltage) Relays.

Degraded Voltage Relay 211T4175-HF-1E, 27N Standard Case (Ref. 8.2.5)
Div II – XY-27B/65E, YZ-27B/65E, XY-27B/65F, YZ-27B/65F
Div II – YN-27D/65E, ZN-27D/65E, YN-27D/65F, ZN-27D/65F

The existing calibration procedures (Ref. 8.2.7 through 8.2.10) include an ALT of ± 0.5 V. Per normal engineering practice and C1-4180 (Ref. 8.2.1) the ALT is normally set equal to VA. By output of this calculation, the calibration procedures will be revised to set ALT = VA.

Relay Errors and Tolerances	**In 120V:**	**Units**	**σ**	**Source**
Errors in % of setting are taken at 120V to bound all possible settings				
VA = Repeatability = 0.10%*120 =0.12 V	0.12	V	2	8.1.3
PSE = Control Pwr Effect = 0.10%*120V (from 100 to 140 Vdc)	0.12	V	2	8.1.3
ATEN = Accuracy Temp Effect – Normal = 0.4%*120 (from 10 to 40C), taken over 20-40C: ATEN = (0.4%*120 V)*(40 – 20)°C / (40 – 10)°C	0.320	V	2	8.1.3
ATEK = Accuracy Temp Effect – LOCA = 0.75%*120 (from 0 to 55C), taken over 20-49C: ATEK = (0.75%*120 V)*(49 – 20)°C / (55 – 0)°C	0.475	V	2	8.1.3 8.1.5
ALT = VA (new – see above)	0.12	V	3	–
As-Found Tolerance = APT = SQRT(VA^2 + LD^2)	0.61	V		–
Potential Transformers				
Accuracy Class 0.3% [3 σ], for max burden use 1.2%	1.2	%	3	8.2.2
PEA = (1.2%*120)*2/3	**0.96**	V	2	–
Relay Voltage Calibration Error Calculation (Equations per C1-4180, Ref. 8.2.1)				
CX = SQRT(CLI^2 + CLO^2) = CLI	0.108	V	3	App. H
EP = ALT if ALT> CX, otherwise EP = CX if ALT < CX	**0.12**	V	3	–
CC = (2/3)*SQRT((5/4)*CX^2 + EP^2)	0.11349	V	2	–
LC = SQRT(CC_1^2 + CC_2^2+ … + CCn^2) = CC	**0.11349**	V	2	–
Relay Voltage Error Calculation (Equations per C1-4180, Ref. 8.2.1)				
AN = 2*SQRT((VA/σVA)^2 + (ATEN/σATEN)^2 + (PSE/σPSE)^2)	0.36222	V	2	–
LAN = AN	0.36222	V	2	–
AK = 2*SQRT((VA/σ_{VA})^2 + (ATEK/σ_{ATEK})^2 + (PSE/σ_{PSE})^2)	0.50441	V	2	–
LAK = AK	**0.50441**	V	2	–
LD = 0.5%*Setpoint = 0.5%*120V	0.6	V	2	5.2

Voltage Channel Error Calculation (Equations per C1-4180, Ref. 8.2.1)				in 4160 V
EAV = (1.645/2)*SQRT(LAK^2 + LC^2 + PEA^2)	**0.89683**	V	1.645	**31.389**
CIEK = (1.645/2)*SQRT(LAK^2 + LC^2 + LD^2 + PEA^2)	**1.02364**	V	1.645	**35.827**
σLER = 0.5*SQRT(LAN^2 + LC^2 + LD^2)	**0.35499**	V	1	**12.425**

Note: All error values are ±

The table below determines new AVs and NTSPs for the degraded voltage UV relay voltages based on the new ALims provided by reference 8.2.14. Because the Technical Specification AVs are for a decreasing voltage setpoint, the lower AV (AVL) is determined via the standard formula for a descending process as stated in Section 3.1. The upper AV (AVU) is then determined by adding the maximum channel error to the operate NTSP. This will set the AVU at the maximum point at which the decreasing voltage can actuate the relay once all the possible sources of error have been considered. The maximum Reset point is determined by dividing the AVU (max possible actuation point) by 0.995 based on the desired 0.5% differential between operate and reset voltages. This maximum possible reset point must be ≤ the Upper Analytical Limit, which is the upper voltage determined in the voltage analysis, (Reference 8.2.14).

Division II Secondary Undervoltage (Degraded Voltage) Voltage Settings – Initial NTSP

Division II Degraded Voltage Relays – Voltage	**4160 V**	**% of 4160 V**	**At P-P Relay**	**At P-N Relay**	**Source**
New Upper ALim	3918.7	94.2			8.1.10
New Max Reset = max SP/0.995	3718.4	89.4			–
New AVU = NTSP + CIEK	3699.8	88.9	105.71	106.80	–
New Reset = NTSP/0.995	3682.4	88.5	105.21	106.30	–
New NTSP (decreasing) rounded up from minimum	3664.0	88.1	104.69	105.77	–
Min NTSP ≥ ALim + CIEK	3663.8	88.1			–
New AVL: AVL ≥ ALim + EAV	3659.4	88.0	104.55	105.64	–
New Lower ALim	3628.0	87.2			8.1.10
Existing Tech Spec AVU	3776.0				8.1.9
Existing NTSP (decreasing)	3702.0				8.1.7
Existing Tech Spec AVL	3628.0				8.1.9

Applying the LER avoidance test (Section 3.1.1), with σ_{LER} = 12.425 V (from Voltage Channel Error Calculation, this section)

$Z_{LER} = (|\ AVL - NTSP\ |)/\sigma_{LER} = (|\ 3659.4 - 3664.0\ |)/12.425 = 0.37$ **FAIL**

Z_{LER} is much less than 1.29, so there is much less than a 90% probability of avoiding violation of the AV

The NTSP will be moved higher, but still within the upper and lower AVs, to provide more margin between the NTSP and the lower AV and ALim for this decreasing voltage trip. The NTSP will be moved to a point halfway between the two AVs.

	4160 V	**% of 4160 V**	**At P-P Relay**	**At P-N Relay**
AVU (from above)	3699.8	88.9	105.71	106.80
AVL (from above)	3659.4	88.0	104.55	105.64
New NTSP (centered between AVL and AVU)	3679.6	88.5	105.13	106.22
NTSP reset = NTSP/0.995	3698.1	88.9	105.66	106.75

Again applying the LER avoidance test:

$Z_{LER} = (|\ AVL - NTSP\ |)/\sigma_{LER} = (|\ 3659.4 - 3679.6\ |)/12.425 = 1.63$ **PASS**

Z_{LER} is ≥ 1.29, so there is greater than a 90% probability of avoiding violation of the AV

The new settings, including ALT and APT, taken around the adjusted NTSP:

Division II Secondary Undervoltage (Degraded Voltage) Voltage Settings – Recommended NTSP

Division II Degraded Voltage Relays - Voltage	**4160 V**	**% of 4160 V**	**At P-P Relay**	**At P-N Relay**	**Source**
New Upper ALim	3918.7	94.2			8.1.10
New Max Reset = max SP/0.995	**3718.4**	**89.4**			–
New AVU = NTSP + CIEK	**3699.8**	**88.9**	105.71	106.80	–
Reset + APT			106.24	107.33	
Reset + ALT			105.78	106.87	–
New Reset = NTSP/0.995	**3698.1**	**88.9**	105.66	106.75	–
Reset - ALT			105.54	106.63	–
Reset – reduced APT			105.08	106.17	–
NTSP + APT > AVU, so reduce APT to 0.58			105.74	106.83	–
NTSP + reduced APT			**105.71**	**106.80**	–
NTSP + ALT			105.25	106.34	–
New NTSP (decreasing) rounded up from minimum	**3679.6**	**88.5**	105.13	106.22	–
NTSP - ALT			105.01	106.10	–
NTSP - reduced APT			**104.55**	**105.64**	–
NTSP - APT > AVU, but reduce APT for symmetry			104.52	105.61	–
Min NTSP ≥ ALim + CIEK	3663.8	**88.1**			–
New AVL: AVL ≥ ALim + EAV	3659.4	88.0	104.55	105.64	–
New Lower ALim	**3628.0**	**87.2**			8.1.10

The as-found value (or APT) is set at ± 0.58 volts to remain within the AVs.

Bus Low Voltage Alarm

The bus low voltage alarm shall be set at a voltage greater than the tripping set voltage and less than the actual bus voltage 4093.44 V (98.4 %), and at a voltage to ensure UV relay will reset with a time delay which shall be (10 sec.) (Ref 8.2.30).

Alarm Setpoint: 4093.44 V
Time Delay: 10 sec.

9.3.3 – Division II Secondary UV (Degraded Voltage) Time Delay

The table below details the instrument accuracy for the elements associated with the Division II LOCA Time Delay Relays

Division II LOCA Time Delay

Degraded Voltage Relay 211T4175-HF-1E, 27N Standard Case (Ref. 8.2.5)
Div II – XY-27B/65E, YZ-27B/65E, XY-27B/65F, YZ-27B/65F
Div II – YN-27D/65E, ZN-27D/65E, YN-27D/65F, ZN-27D/65F

For conservatism, those errors that are based on % of setting will use a setting that is larger than the actual setpoint. A setting of 7.31 seconds is chosen for this purpose. It is an acceptable, conservative value because it is larger than the setpoint plus the ALT (7.20 seconds, on next page).

Time Delay Error and Tolerance	**Value**	**Units**	**σ**	**Source**
Maximum setting to use with % setting errors – see above	7.31	sec		–
VA = greater of 20 mS or 10% of setting	0.73	sec	2	8.1.3
ALT = new – see below	0.500	sec	3	–
As-Found Tolerance = APT = SQRT(VA^2 + LD^2)	0.73	sec		–
Relay Time Calibration Error Calculation (Equations per C1-4180, Ref. 8.2.1)				
CX = SQRT(CLI^2 + CLO^2) = CLI	0.00068	sec	3	App. H
EP = ALT if ALT> CX, otherwise EP = CX if ALT < CX	**0.500**	sec	3	–
CC = (2/3)*SQRT(2*CX^2 + EP^2)	0.33333		2	–
LC = SQRT(CC_1^2 + CC_2^2+ … + CCn^2) = CC	**0.33333**	sec	2	–
Relay Time Error Calculation (Equations per C1-4180, Ref. 8.2.1)				
AK = 2*(VA/σ_{VA}) = AN **	0.731	sec	2	–
LAK= AK = LAN **	**0.731**	sec	2	–
LD = 0.5%*setting	**0.037**	sec	2	5.2
Time Channel Error Calculation (Equations per C1-4180, Ref. 8.2.1)				
EAV = (1.645/2)*SQRT(LAK^2 + LC^2)	**0.6608**	sec	1.645	–
CIEK = (1.645/2)*SQRT(LAK^2 + LC^2 + LD^2)	**0.6615**	sec	1.645	–
σLER = 0.5*SQRT(LAN^2 + LC^2 + LD^2)	**0.4021**	sec	1	–

All error values are ±.

** The manufacturer does not specify an accuracy temperature effect for the time delay actuation. Thus the normal and post-accident accuracies are the same, so AN = AK and LAN = LAK.

Calibration ALT is increased from existing ±0.05 seconds to ±0.5 seconds. Good practice is to set the ALT equal to the VA when possible, or to use at least one half of the VA. Since the VA is ±0.731 seconds, the existing ±0.05 seconds is an order of magnitude too small. Thus it is increased in this analysis to a more realistically achievable ±0.5 seconds, and by output of this calculation will be changed in the calibration procedure.

Per Section 3.1.2, the as-found tolerance is based on the APT from Ref. 8.2.1. As a maximum, it will be set to the SRSS of the repeatability and drift, and will be reduced as needed to stay within the AVs. A smaller as-found tolerance is conservative, because it will provide earlier indication of degraded performance.

The upper Alim for the LOCA time delay supports the 13 second EDG start time from the LOCA analysis (Ref. 8.2.19, UFSAR Tables 6.3-7 & 8.3-5). The EDG start circuit includes a separate time delay relay, and an additional 0.18 seconds is required to account for the closure times of the EDG output and RHR pump motor breakers. Thus the upper ALim for the DV LOCA time delay is determined by subtracting the maximum EDG start timer delay and 0.18 seconds from the 13 second EDG start time for LOCA. Appendix G contains the determination of error associated with the EDG start timer relay.

The Technical Specification AVs for the LOCA condition degraded voltage relays are for an increasing time setpoint, so a new upper AV (AVU) is calculated via the standard formula for an ascending process as stated in Section 3.1. The lower ALim is conservatively chosen as 5.50 seconds to be greater than the Core Spray pump acceleration time (Ref. 8.2.14). The new lower AV (AVL) for LOCA conditions is calculated via the standard formula for a descending process as stated in Section 3.1. The new NTSP is calculated as the average of the upper and lower ALims rounded to the nearest 0.1 second.

Division II DV Relay LOCA Time Delay	**Value**	**Units**	**Source**
Upper ALim (13 sec DG Start – DG timer relay max time)	7.97	sec	App. G
New Tech Spec AVU = ALim – EAV	**7.31**	**sec**	–
Max SetPt = ALim – CIEK	7.31	sec	–
NTSP + APT > AVU, so reduce APT to 0.54 sec	7.43	sec	–
NTSP + reduced APT	**7.24**	sec	–
NTSP + ALT	7.20	sec	–
New NTSP (increasing) = Average of ALims, rounded to 1 digit	**6.7**	**sec**	–
NTSP – ALT	6.20	sec	–
NTSP – reduced APT	**6.16**	sec	–
NTSP – APT < AVL, so reduce APT to 0.54 sec	5.97	sec	–
Min SetPt = ALim + CIEK	6.16	sec	–
New Tech Spec AVL = ALim + EAV	**6.16**	**sec**	–
Lower ALim	5.50	sec	8.1.12
Average of ALims: New NTSP, to be set in the center of the range.			

Inspection of these values shows that the setpoint is within the range of maximum and minimum setpoint values with respect to the upper and lower ALims and so is acceptable. The new AVs are separated from their respective ALims by the required uncertainties.

Applying the LER avoidance test (Section 3.1.1), with σ_{LER} = 0.4021 sec (from Time Channel Error Calculation, this section)

$Z_{LER} = (|\text{AVU - NTSP}|)/\sigma_{LER} = (|7.31 - 6.7|)/0.4021 = 1.52$ **PASS**

$Z_{LER} \geq 1.29$, so there is a greater than 90% probability of avoiding violation of the AV

The as-found value (or APT) is set at ± 0.54 seconds to remain within the AVs.

The table below details the instrument accuracy for the elements associated with the Division II Non-LOCA Time Delay Relays. Since no drift value is provided for these relays, an assumed loop drift of 0.5% of setting (Assumption 5.2) is used in the calculation of total error.

Division II Degraded Voltage Non-LOCA Timer Relays Agastat E7012PD (Ref. 8.2.5)
Div II Bus 65E: 1RW62 and Div II Bus 65F: 1RX62

For conservatism, those errors that are based on % of setting will use a setting that is larger than the actual setpoint. A setting of 15.05 seconds is chosen for this purpose. It is an acceptable, conservative value because it is equal to the NTSP plus the ALT.

The existing calibration procedures (Ref. 8.2.7 through 8.2.10) include an ALT of ± 1.0 sec. Per C1-4180 (Ref. 8.2.1) the ALT is normally set equal to VA, unless noted otherwise. The existing ALT of 1 sec is larger than the VA, and results in too large of a total error to stay within the Tech Spec AVs. Thus the ALT will be reduced to slightly more than one half of the VA, or 0.400 seconds. By output of this calculation, the calibration procedures will be revised to set ALT equal to 0.400 sec.

Non- LOCA Div. II Time Delay Error and Tolerance	**Agastat Only**	**Units**	**σ**	**Source**
Agastat setting to use with % setting errors	15.050	sec		
VA = 5% of setting	0.753	sec	3	8.1.4
ALT (new - see above)	0.400	sec	3	–
As-Found Tolerance = APT = SQRT(VA^2 + LD^2)	0.756	sec		–
Relay Time Calibration Error Calculation (Equations per C1-4180, Ref. 8.2.1)				
CX = SQRT(CLI^2 + CLO^2) = CLI	0.00375	sec	3	App. H
EP = ALT if ALT> CX, otherwise EP = CX if ALT < CX	**0.400**	sec	3	–
CC = (2/3)*SQRT(2*CX^2 + EP^2)	0.26669	sec	2	–
LC = SQRT(CC_1^2 + CC_2^2+ … + CCn^2) = CC	**0.26669**	sec	2	–
Relay Time Error Calculation (Equations per C1-4180, Ref. 8.2.1)				
AK = 2*(VA/σ_{VA}) = AN **	0.502	sec	2	–
LAK= AK = LAN **	**0.502**	sec	2	–
LD = 0.5%*Setting	**0.075**	sec	2	5.2
Time Channel Error Calculation (Equations per C1-4180, Ref. 8.2.1)				
EAV = (1.645/2)*SQRT(LAK^2 + LC^2)	**0.4675**	sec	1.645	–
CIEK = (1.645/2)*SQRT(LAK^2 + LC^2 + LD^2)	**0.4716**	sec	1.645	–
σLER = 0.5*SQRT(LAN^2 + LC^2 + LD^2)	**0.2867**	sec	1	–

Note: All errors are ±.

** The manufacturer does not specify an accuracy temperature effect for the time delay actuation. Thus the normal and post-accident accuracies are the same, so AN = AK and LAN = LAK.

For non-LOCA conditions, the output of the ABB undervoltage relay (set at the LOCA time delay) starts a second Agastat timer relay. Thus the total non-LOCA time delay is the combination of the time delay from the degraded voltage undervoltage ABB relay (set at the LOCA time delay) and the time delay of the Agastat timer relay. The Technical Specification non-LOCA time AVs must be shown to bound the combination of the individual time AVs for the undervoltage relay LOCA time plus the non-LOCA timer relay (Agastat) time. The total NTSP for the non-LOCA time operate point is the undervoltage relay LOCA time NTSP plus the NTSP of the timer relay.

Division II Non-LOCA Time Delay Agastat Settings

Division II Degraded Voltage Non-LOCA Timer Relay (Agastat)	**Total Time**	**Time at Agastat**	**Units**	**Source**
Min Total Upper ALim (add 3.5 sec) for max EDG start	28.598		sec	–
Min Upper ALim Implied by existing AVU: ALim ≥ AVU + EAV	23.598		sec	–
Agastat portion of Min Upper ALim: $ALim_{AG} \geq AVU_{AG}$ + EAV		15.628	sec	–
Existing Tech Spec AVU	**22.47**		sec	8.1.9
Agastat portion of AVU: AVU – AVU_{LOCA}		15.161	sec	–
Max Possible setpoint actuation w/ existing NTSP: NTSP + CIEK		15.157	sec	–
Max NTSP for Upper ALim: Max NTSP ≤ ALim – CIEK		15.121	sec	–
NTSP + APT> AVU, so reduce APT to 0.48 sec		15.406	sec	–
NTSP + reduced APT		**15.130**	sec	–
NTSP + ALT		15.050	sec	–
New NTSP (increasing)	**21.35**		sec	8.1.7
Agastat NTSP: Total NTSP – $NTSP_{LOCA}$		**14.650**	sec	–
NTSP – ALT		14.250	sec	–
NTSP - reduced APT		**14.170**	sec	–
NTSP - APT < AVL, so reduce APT to 0.48 sec		**13.894**	sec	–
Min Possible setpoint actuation w/ existing NTSP: NTSP – CIEK		14.179	sec	–
Min NTSP for Lower ALim: Min NTSP ≥ ALim + CIEK		14.173	sec	–
Existing Tech Spec AVL	**20.33**			8.1.9
Agastat portion of AVL_{AG}: AVL – AVL_{LOCA}		14.169	sec	–
Max Lower ALim Implied by existing AVL: ALim ≤ AVL –EAV	19.202		sec	–
Agastat portion of Max Lower ALim: $ALim_{AG} \leq AVL_{AG}$ – EAV		13.702	sec	–

The existing total setpoint has been reduced, and a new Agastat time delay setpoint has been determined to ensure that the setpoint is maintained between the AVs.

Applying the LER avoidance test (Section 3.1.1), with σ_{LER} = 0.2867 sec (from Voltage Channel Error Calculation, this section)

$Z_{LER} = (|\text{AVU - NTSP}|)/\sigma_{LER} = (|15.161 - 14.650|)/0.2867 = 1.78$ V **PASS**

$Z_{LER} \geq 1.29$, so there is a greater than 90% probability of avoiding violation of the AV

The as-found value (or APT) is set at ± 0.48 seconds to remain within the AVs.

9.3.4 480V Primary Undervoltage

The 480V bus primary UV devices should coordinate with the 4160V primary device. Loss of voltage at the 4160V buses initiates the EDGs. The 4160V buses should trip first to prevent isolation of 480V bus without EDG initiation. There is typically a 2-3% voltage drop between the 480 and 4160V buses. To assure selectivity, all 480 UV relays are set at 206.4 V (43%) with a 2 second minimum inverse time delay.

Trip Setpoint: 206.4 V
Time Delay: 2 sec

9.4 Setpoint Determination and Acceptance Criteria for Division II RHR Building

9.4.1 4160 Primary Undervoltage

All RHR 4160V UV relays are set at 2247 V (54%) with a 2 second minimum inverse time delay.

Trip Setpoint: 2247 V
Time Delay: 2 sec.

9.4.2 480V Primary Undervoltage

The 480V bus primary UV devices should coordinate with the 4160V primary device. Loss of voltage at the 4160V buses initiates the EDGs. The 4160V buses should trip first to prevent isolation of 480V bus without EDG initiation. There is typically a 2-3% voltage drop between the 480 and 4160V buses. To assure selectivity, all 480 UV relays are set at 206.4 V (43%) with a 2 second minimum inverse time delay.

Trip Setpoint: 206.4 V
Time Delay: 2 sec.

9.5 Division I & II Secondary Undervoltage Scheme for Swing Bus

9.5.1 480 Volt Buses - Reactor Building

- Bus 72C Position 3C Feed to Swing Bus MCC 72CF (Normal)
- Bus 72F Position 5C Feed to Swing Bus MCC 72CF (Alternate)

This section determines the voltage setting for the undervoltage relays and the time setting for the time delay relay in both Divisions I and II. The additional undervoltage and time delay relays are an enhancement to the existing system. This scheme is for detecting a degraded voltage condition on the 480V swing bus after closure of the EDG output breakers. This scheme detects when the voltage at the swing bus is less than the required voltage level for the motor-operated valves (MOV) connected to the swing bus and initiates a transfer of the swing bus feed to the other Division.

9.5.2 480 Volt Buses - Reactor Building Swing Bus Acceptance Criteria and Analysis

The system conditions for this analysis are as follows:

- Loss of off-site power (off-site breaker open).
- Loss of coolant accident coincident with loss of off-site power.
- Degraded (voltage regulator failure) or no voltage on the 480V buses feeding Swing Bus MCC 72C-F occurs just after the time of closing the EDG output breaker.

The relays are set to trip when the 480V bus voltage has degraded to the point when safety systems fed from Swing Bus MCC 72C-F should not be operated as continued operation may cause damage to safety system equipment.

There are two acceptance criteria by which to establish secondary (degraded) UV setpoints:

1. The steady state voltage of the swing bus must not drop below the allowable limit required to operate the most limiting motor-operated valve.
2. The setpoint selected should be low enough to prevent unnecessary transfer of the swing bus.

Undervoltage Relay Setting

Criterion 1: (The voltage limit that the swing bus must not drop below to allow operation of the most limiting motor-operated valve at a degraded steady state voltage.)

The minimum voltage required at MCC 72C-F is 93.07% of 480V per Section 10.2.3 of Ref. 8.2.14. The voltage drop from Bus 72C to MCC 72C-F is 3V per Ref. 8.2.36. The voltage drop from Bus 72F to MCC 72C-F is 4V per Ref. 8.2.36. This results in required voltages at Bus 72C and Bus 72F, of 93.7% and 93.91%, respectively. Operation of the valves fed from this MCC is acceptable with voltages maintained above these values.

The undervoltage relays on each bus were set to ensure bus voltage will not drop below 94.00%. The setpoints for these relays are calculated in Appendix B and are summarized below.

Parameter	Div 1	Div 2
Max Reset	96.57%	96.57%
Max Dropout	96.09%	96.09%
Setpoint	95.04%	95.04%
Lower Operating Limit	94.00%	94.00%
Min Req'd Volts	93.70%	93.91%

Criterion 2: (The setpoint should be low enough to prevent unnecessary transfer of the swing bus.)

The setpoint calculation for this relay in Appendix B calculates a reset value of 96.57%. EDG output voltage is very precise and maintains voltage regulation within ±½% of 4160V (Ref. 8.2.37). Applying this tolerance to the voltage regulator setting results in a minimum expected voltage at the EDG terminals of 4100V (Ref.

8.2.36). This voltage results in a voltage of 476V (99.17%) at Bus 72C (Ref. 8.2.36). Bus 72F is fed via a voltage regulator that controls the voltage to 480V ±1% (Ref. 8.2.14). Therefore, the voltage will be maintained above the maximum reset value of the relays preventing an unnecessary transfer of the swing bus. A single failure of the voltage regulator resulting in Bus 72C or Bus 72F voltages below the relay set points (including tolerances) will result in a transfer of the swing bus to the opposite division.

Based on the above evaluation, power to MCC 72C-F will be maintained to operate the motor operated valves fed from swing bus MCC 72C-F without an unnecessary transfer to the opposite division.

Time Delay (TD) Setting

The time delay for the secondary undervoltage scheme must meet several acceptance criteria.

1. It should allow for the worse case motor starts (RHR and core spray).
2. It must not delay the ECCS injection timing.
3. It should be as short as possible to reduce equipment damage due to undervoltage.

Criterion 1: (TD should allow for the worse case motor starting transients at nominal voltages (RHR and core spray sequential starts)).

Large motor starts will drop the EDG voltage below the set point. The time delay must be long enough to prevent tripping for this transient. Based on preoperational testing, PRET R3000.003 (Ref. 8.2.23) performed on Division I EDGs on August 14, 1984, and Division II EDGs on August 18, 1984, it was concluded that the recovery time for the EDG voltage is as follows:

	EDG 11	EDG 12	EDG 13	EDG 14
RHR Pump Start	0.6 sec	0.5 sec	0 .8 sec	1.0 sec
CS Pump Start	0.3 sec	0.2 sec	0.3 sec	0.3 sec

See Attachment D for EDGs test characteristics. For Criteria 1 the time delay has to be longer than one (1) second.

Criterion 2: (TD must not delay the ECCS injection timing.)

The time delay for the new relays must not delay the power availability for the ECCS injection. In the present design, there is a 5 second gap for the load sequencer (I-2714-35, Ref. 8.2.33 and I-2714-36, Ref. 8.2.34) of EDG 12 (Division I) to pick up the swing bus load in case there is an EDG 14 failure. This 5 second period can be used to set the time delay for UV relays to detect any true degraded voltage condition. Therefore, the total delay can be as high as 5 seconds. The total time for ECCS injection is addressed in Safety Evaluation 89-0186 (Ref. 8.2.24).

Criterion 3: (TD should be as short as possible to reduce equipment damage due to undervoltage.)

The time delay shall be as short as possible to avoid damaging any QA-1 equipment since the QA-1 motors can withstand the locked motor current for 15 seconds, as per DC-6348, Vol. I (Ref. 8.2.38) and the motors under degraded voltage will move slower than normal or get stalled and, in either case, the motor will have more current than its full load current. Therefore, 15 seconds can be used as upper boundary. Time delay (TD) setting should be below 15 seconds.

Conclusion

- From Criteria 1 above, the TD for the degraded UV scheme has to be larger than one (1) second.
- From Criteria 2 above, the time delay can be as high as 5 seconds,
- From Criteria 3 above, the time delay has to be less than 15 seconds.

Undervoltage Relay Time Response

The responding time for the undervoltage relay type (ITE-27) (Ref. 8.2.3) was calculated from the relay characteristic (Appendix B) and it varies between 0.2 to 1.3 seconds +/- 10 %, tolerance per Procedure 35.318.008 (ITE Voltage Relay Testing) (Ref. 8.2.39). Therefore, the response times are as follows:

- Maximum response time for the undervoltage relay = 1.3+ 0.13 = 1.43 seconds.
- Minimum response time would be 0.2 - 0.02 = 0.18 seconds.

This was determined based on setting the time response for the UV relay at tap setting No. 1.

<u>Total Time Delay for the Secondary Undervoltage Scheme</u>

The total time delay for the scheme should not exceed 5 seconds since the present design has a time delay of 5 seconds for the load sequencer of EDG 12 as shown above. The total time delay for the scheme consists of:

- Maximum response time is the UV relay response plus time delay relay.
- Minimum response time allowable will be the time needed to override a large motor start on the EDG.

The maximum responding time for the UV relay is 1.43 seconds. Therefore, the time delay relay time shall not exceed 5.0 - 1.43 = 3.57 seconds.

The minimum response time allowable will be the time needed to override a large motor start on the EDG. Per the PRET test results contained in EF2-72330 (Ref. 8.2.31), the longest RHR or core spray start is about 1 second.

<u>Time Delay Relay Setting</u>

In order to meet all criteria requirements above, the total responding time for the time delay relay shall be more than 1 second and lower than 3.57 seconds.

Minimum Required Time:	1 second
Margin 200%	2 seconds
Setting Margin +/- 5%: (10% band)	0.3 seconds
TOTAL	3.3 seconds
Use Upper Setting of	3.4 seconds

Therefore the setting will be:

Lower Limit:	3.0 seconds
Setpoint:	3.2 seconds
Upper Limit:	3.4 seconds

The total time maximum time delay will be: 3.4 + 1.43 = 4.83 seconds.

Conclusion:
The time delay relay setting meets all the requirements above. Acceptance criteria for testing the resetting of the relay shall be specified on the relay setting sheet.

10.0 Acceptance Criteria

The specific acceptance criteria of this calculation are contained within calculation Sections 3 and 9.

APPENDIX A

EF-2-FSAR

ITEM 222.31A

Your response to Item 222.31 states that manual operator action is required to isolate the emergency buses from a degraded voltage condition. We find this to be unacceptable and require the installation of an automatically initiated protection scheme which shall satisfy the following criteria.

a. Class lE equipment shall be utilized and shall be physically located at and electrically connected to the emergency switchgear.

b. An independent scheme shall be provided for each Division of emergency power.

c. The selection of voltage and time delay set points shall be determined from an analysis of the voltage requirements of the safety-related loads at all onsite system distribution levels.

d. The time delay selected shall be based on the following conditions:

1. The allowable time delay, including margin, shall not exceed the maximum time delay associated with the availability of power that is assumed in the accident analysis;

2. The time delay shall minimize the effect of short duration disturbances from reducing the availability of the offsite power source(s); and

3. The allowable time duration of a degraded voltage condition at all distribution system voltage levels shall not result in failure of safety systems or components.

e. The voltage monitors shall automatically initiate the disconnection of offsite power sources by tripping the emergency bus feeder breaker whenever the voltage set point and time delay limits have been exceeded and the associated diesel generator shall be signaled to start and accept load.

f. The set points for this scheme shall be design dependent but should approximate the following envelopes:

1. Voltage set point between 87 and 90 % of nominal.

2. Time delay setting of between 6 and 10 seconds.

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(CONT'D)

g. Capability for test and calibration during power operation shall be provided.

h. Annunciation must be provided in the control room for any bypasses incorporated in the design.

i. The technical specifications shall include limiting conditions for operation, surveillance requirements, and trip set points with minimum and maximum limits.

RESPONSE

Refer to revised Subsection 8.2.2.5 of the FSAR.

APPENDIX B

LPCI Swing Bus Relay Error

The tables below detail the instrument accuracy for the elements associated with the LPCI Swing Bus Relays.

Per normal engineering practice and C1-4180 (Ref. 8.2.1) the ALT is normally set equal to VA. By output of this calculation, the calibration procedures will be revised to set ALT = VA.

Relay Errors and Tolerances	**In 120V:**	**Units**	**σ**	**Source**
Errors in % of setting are taken at 120V to bound all possible settings				
VA = Repeatability = 0.2 V	0.2	V	2	8.1.2
PSE = Control Pwr Effect = 0.2 V per 10V change in control voltage. Taken over 105 to 138.5 V: PSE = (138.5 – 105V) * 0.2V / 10V	0.67	V	2	8.1.2 8.1.13
ATEK = Temp Effect = 0.5V from 20-40 C, extend to 49 C: ATEK = (0.5 V)*(49 – 20)°C / (40 – 20)°C	0.725	V	2	8.1.2 8.1.5
ALT = VA (new)	**0.2**	**V**	3	–
Potential Transformers				
Accuracy Class 0.3% [3 σ], for max burden use 1.2%	1.2	%	3	8.2.2
PEA = (1.2%*120/100)*2/3	**0.96**	V	2	–
Relay Voltage Calibration Error Calculation (Equations per C1-4180, Ref. 8.2.1)				
CX = SQRT(CLI^2 + CLO^2) = CLI	0.108	V	3	App. H
EP = ALT if ALT> CX, otherwise EP = CX if ALT < CX	**0.2**	V	3	–
CC = (2/3)*SQRT((5/4)*CX^2 + EP^2)	0.15575	V	2	–
LC = SQRT(CC_1^2 + CC_2^2+ … + CCn^2) = CC	**0.15575**	V	2	–
Relay Voltage Error Calculation (Equations per C1-4180, Ref. 8.2.1)				
AK = 2*SQRT((VA/σ_{VA})^2 + ($ATEK/\sigma_{ATEK}$)^2 + (PSE/σ_{PSE})^2)	1.00724	V	2	–
LAK = AK	**1.00724**	V	2	–
LD = 0.5%*Setpoint = 0.5%*120V	**0.6**	V	2	5.2

Voltage Channel Error Calculation (Equations per C1-4180, Ref. 8.2.1)				In 480 V
EAV = (1.645/2)*SQRT(LAK^2 + LC^2 + PEA^2)	**1.15161**	**V**	1.645	**4.606**
CIEK = (1.645/2)*SQRT(LAK^2 + LC^2 + LD^2 + PEA^2)	**1.25290**	**V**	1.645	**5.012**

Note: All error values are ±

LPCI Swing Bus Relay Settings	**In 480 V:**	**% of 480 V**	**at Relay 120 V**
Max Reset = max SP/0.995	**463.54**	**96.57**	115.89
Reset (increasing) 0.5% above SP (Reset = SP/0.995)	**458.50**	**95.52**	**114.63**
Max Possible actuation of NTSP	461.22	**96.09**	115.31
NTSP (decreasing)	**456.21**	**95.04**	**114.05**
Min NTSP ≥ LOL + (1.645/2)*SQRT(LAT^2 + LD^2 + LC^2 + PEA^2)	456.21	**95.04**	114.05
Lower Operating Limit (LOL) = Min possible actuation of Operate Setpt	451.20	**94.00**	112.80

New As-Left Tolerance ALT = ±0.2 V

APPENDIX F

120 KV Division 1 Parameters required for Grid Adequacy Study AG80

Fermi Degraded Grid Relays Monitor Voltage at	120 kV bus values used in previous year study	120 kV bus values to be used in current year study	Listed values Acceptable
System Service Monitored	SS64	SS64	
Time to Separate from Grid if Voltage goes to 0 V	2 seconds	___ seconds	
Percentage of Nominal Voltage (on low side of SS transformer) and Time Required to Cause Separation from Grid (timer start to trip) Reset Voltage to reset UV Relays	< 96.9% V for > 44.0 sec 99.8% V	< ____% V for > ____ sec _____% V	
Approximate Equivalent Percentage of Nominal Voltage on the Grid Bus Required to Cause Separation from Grid	< 96.4 % > 99.3 % to reset	< _____ % ____ % to reset	
Percentage of Nominal Voltage (on low side of SS transformer) which will Cause Sensor to Alarm	< 98%	< ___%	
Percentage of Nominal Voltage (on low side of SS transformer) which will trigger primary Under-voltage relay to separate bus from the grid	< 73%	< ___%	
Alarm Equivalent Percentage of Nominal Voltage on the Grid Bus Required to Cause Sensor to Alarm	< 101 %	< ___ %	
LOCA loading from DC-5003, Vol.I (Ref. 8.2.32)	5.803 MW and 2.636 Mvar	______MW and ______Mvar	
Critical System Service Loads Simulated:	22.958 MW and 16.066 Mvar SS64: 12.479 MW and 6.073 Mvar	______ MW and ______ Mvar SS64: ______ MW and _____ Mvar	
Verify that the provide Divisional Loading bounds the real time loading plus LOCA loading	YES		
SS64 Transformer Tap	-5% 15.54/4.16kV	___% 15.54/4.16kV	
Prepared by: Print:	Sign:	Date:	
Reviewed by: Print:	Sign:	Date:	

APPENDIX F

Assumptions required for Grid Adequacy Study AG80

The case used for the study are to be modeled to simulate load levels and generation dispatch to correlate to the expected conditions for the year that the study is performed.

At least Four (4) cases will be built and used during the study. If further cases are required to verify system stability then the study model will be expanded to address all issues.

Based on the known system requirements the four cases will be sufficient. The Fermi 120kV peaking generation was modeled offline in all four cases, to stress the area conditions.
The four cases are as follows:

- The first case, will be summer peak case with the expected full generation dispatch was modeled and is designated Case 100N (normal).

- The second case will be summer peak load, but with several nearby generators modeled out of service (Monroe 2, Trenton Channel 9 & Whiting 3 off). This case was built to stress the voltage conditions in the Fermi area and is designated Case 100S (stressed).

- The third case will be based on the original peak case, 100N, Case 100EF represents E. Fermi 2 unit offline.

- The fourth case will be an 80% (conforming load scaled down only) ITCT/Michigan Electric Transmission Company (METC) load case, with an economic order generation reduction. This will be the system condition ITCT uses to test transient stability, since reduced load and reduced generation is the most severe for transient stability.

APPENDIX F Page 3 of 10
Main Turbine Generator Parameters

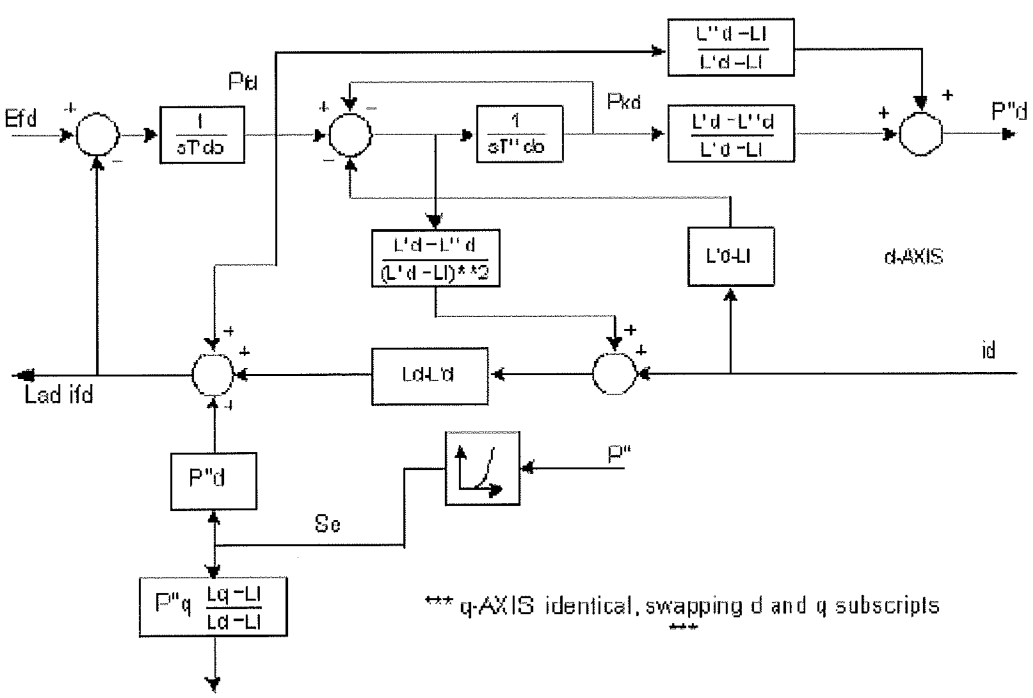
PTI PSS/E DYNAMIC MODEL DESCRIPTION

PTI - POWER TECHNOLOGIES INTERNATIONAL is the company which develops the PSS/E software
PSS/E - THE POWER SYSTEM SIMULATION FOR ENGINEERING software is used in RFC DMWG base cases for ITC/METC areas

GENERATOR MODEL

GENROU Round rotor generator model (Quadratic Saturation)

T'DO	D-axis transient rotor time constant, second
T"DO	D-axis sub-transient rotor time constant, second
T'QO	Q-axis transient rotor time constant, second
T"QO	Q-axis sub-transient rotor time constant, second
H	Inertia constant, second
D	Speed damping factor, pu
XD	D-axis synchronous reactance, pu
XQ	Q-axis synchronous reactance, pu
X'D	D-axis transient reactance, pu
X'Q	Q-axis transient reactance, pu
X"D=X"Q	D-axis sub-transient reactance, pu
XL	Stator leakage reactance, pu
S(1.0)	Saturation factor at 1.0 pu flux
S(1.2)	Saturation factor at 1.2 pu flux



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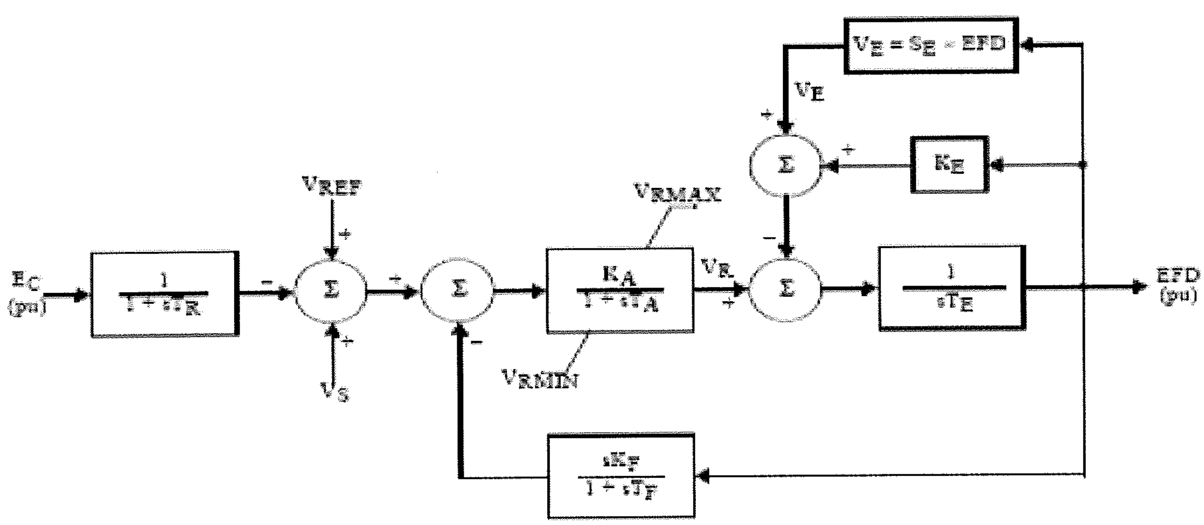
Reviewed by: Print:	Sign:	Date:

APPENDIX F
Main Turbine Generator Parameters

EXCITATION SYSTEM MODEL

IEEET1	1968 IEEE type 1 excitation system model	
	TR	Transducer time constant, second
	KA	Voltage regulator gain
	TA	Voltage regulator time constant, second
	VRMAX	Maximum control element output, pu
	VRMIN	Minimum control element output, pu
	KE	Exciter field resistance line slop margin, pu
	TE	>0, exciter field time constant, second
	KF	Rate feedback gain, pu
	TF	>0, rate feedback time constant, second
	SWITCH	Required entry of zero
	E1	Exciter flux at knee of curve, pu
	S(E1)	Saturation factor at knee
	E2	Maximum exciter flux, pu
	S(E2)	Saturation factor at maximum flux



V_S = VOTHSG + VUEL + VOEL

Note: S_E is the saturation function

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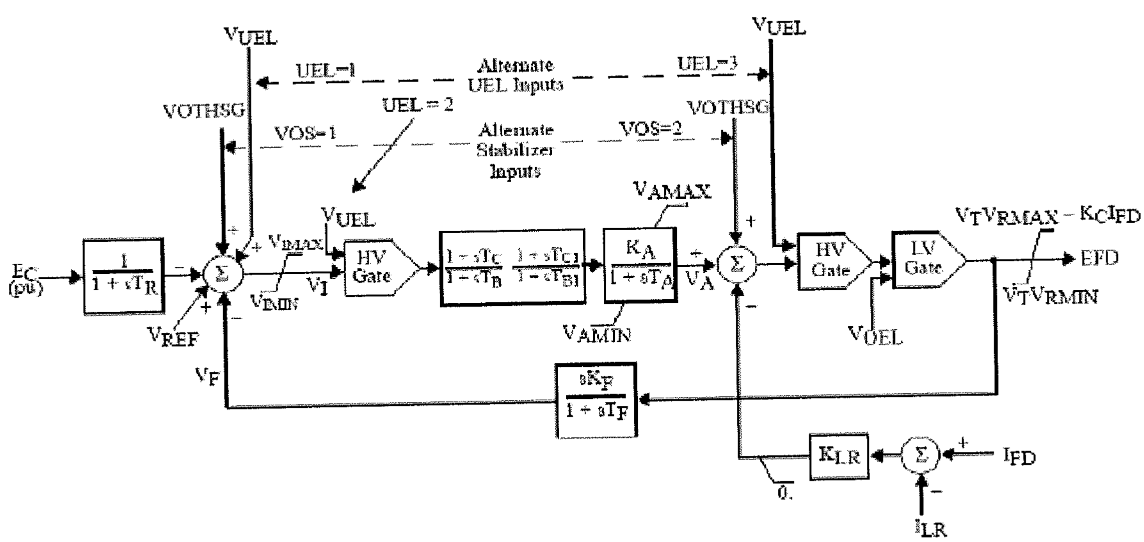
APPENDIX F
Main Turbine Generator Parameters

ESST1A		1992 IEEE Type ST1A Excitation System, a potential source controlled recrified-exciter excitation system
	UEL	1 - VUEL voltage output of alternate UnderExcitation Limiter as the voltage summing input to forward path 2 - VUEL voltage output of alternate UnderExcitation Limiter as the voltage error signal input to the forward path HV* gate 3 - VUEL voltage output of alternate UnderExcitation Limiter as the gate input to the controller HV* gate
	VOS	1 - VOTHSG voltage output of alternate PSS as the voltage summing input to forward path 2 - VOTHSG voltage output of alternate PSS as the voltage summing input to the controller HV* gate
	TR	Filter time constant, second
	VIMAX	Maximum error signal , pu
	VIMIN	Minimum error signal, pu
	TC	Forward path lead time constant, second
	TB	Forward path lag time constant, second
	TC1	Forward path lead time constant, second
	TB1	forward path lag time constant, second
	KA	Voltage regulator gain
	TA	Voltage regulator time constant, second
	VAMAX	Maximum control element output, pu
	VAMIN	Minimum control element output, pu
	VRMAX	Maximum controller output, pu
	VRMIN	Minimum controller output, pu
	KC	Excitation system regulation factor, pu
	KF	Rate feedback gain
	TF	>0, rate feedback time constant, second
	KLR	The gain of the field current limiter, pu
	ILR	The start current setting of the field current limiter



* High-value gate (HV) is an auctioneering circuit which gives control to the larger of the voltage regulator and UEL

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DYNAMIC MODELS AND DATA IN AREA 219 ITC

Generator

GENROU	BUS NAME	EXPANDED BUS NAME	UNIT ID	KV	UNIT MVA BASE	T'D0	T"D0	T'Q0	T"Q0	H
264854	19ENFPP	ENRICO FERMI 2	1	22.0	1350.0	8.600	0.046	1.080	0.068	4.990

DAMP	XD	XQ	X'D	X'Q	X"D**	XL	S(1.0)	S(1.2)
1.0	2.0100	1.8700	0.3730	0.5880	0.2740	0.2400	0.1100	0.4800

Excitation System**

ESST1A	BUS NAME	EXPANDED BUS NAME	UNIT ID	KV	UNIT MVA BASE	UEL*	VOS*	TR	VIMAX	VIMIN
264854	19ENFPP	ENRICO FERMI 2	1	22.0	1350.0	1	1	0.000	0.090	-0.077

TC	TB	TC1	TB1	KA	TA	VAMAX	VAMIN	VRMAX	VRMIN	KC	KF
1.000	1.830	0.100	0.330	110.000	0.003	5.430	-4.620	5.430	-4.620	0.000	0.000

** Modified by Ming Wu in ITC according the updated data from Joseph Caffrey in DTE 8/28/2008
* Assumed by Ming Wu in ITC, see DYNAMIC MODEL DESCRIPTION sheet for further explanation 8/28/2008

APPENDIX F
Fermi 2 Peaker Parameters

PTI PSS/E DYNAMIC MODEL DESCRIPTION

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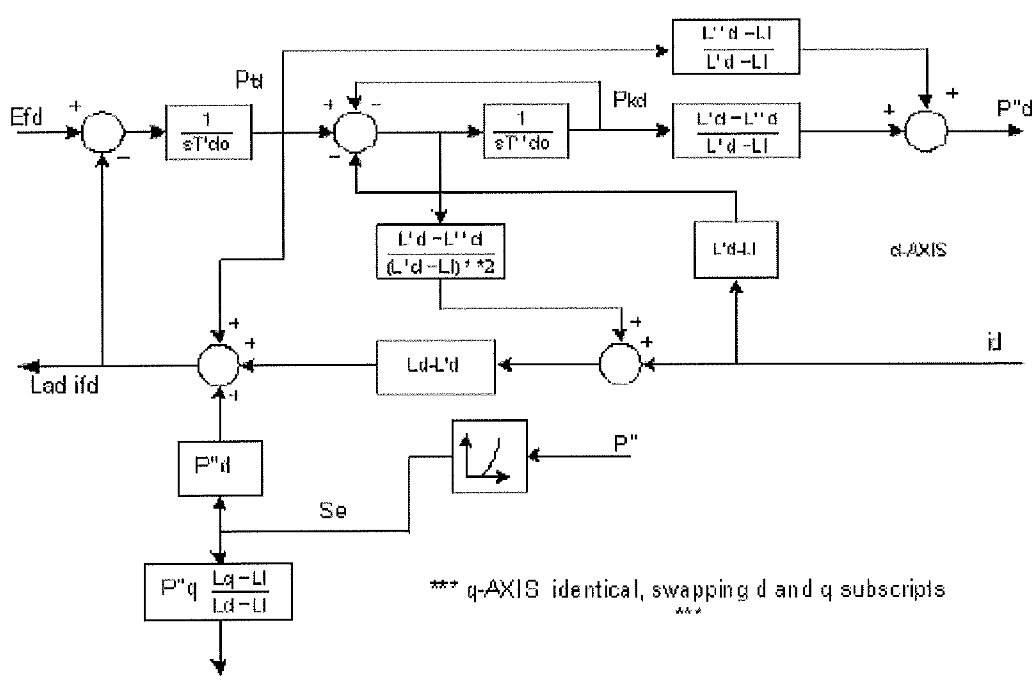
H	Inertia constant, second
D	Speed damping factor, pu
XD	D-axis synchronous reactance, pu
XQ	Q-axis synchronous reactance, pu
X'D	D-axis transient reactance, pu
X'Q	Q-axis transient reactance, pu
X"D=X"Q	D-axis sub-transient reactance, pu
XL	Stator leakage reactance, pu
S(1.0)	Saturation factor at 1.0 pu flux
S(1.2)	Saturation factor at 1.2 pu flux



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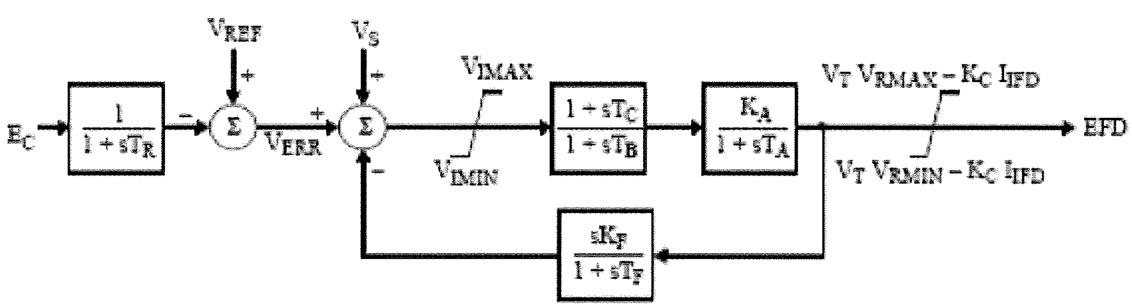
EXCITATION SYSTEM MODEL

EXST1 1981 IEEE type ST1 excitation system model

TR	Filter time constant, second
VIMAX	Maximum error, pu
VIMIN	Minimum error, pu
TC	Lead time constant, second
TB	Lag time constant, second
KA	Gain
TA	Time constant, second
VRMAX	Maximum controller output, pu
VRMIN	Minimum controller output, pu
KC	Excitation system regulation factor, pu
KF	Rate feedback gain
TF	>0, Rate feedback time constant, second



V_S = VOTHSG + VUEL + VOEL

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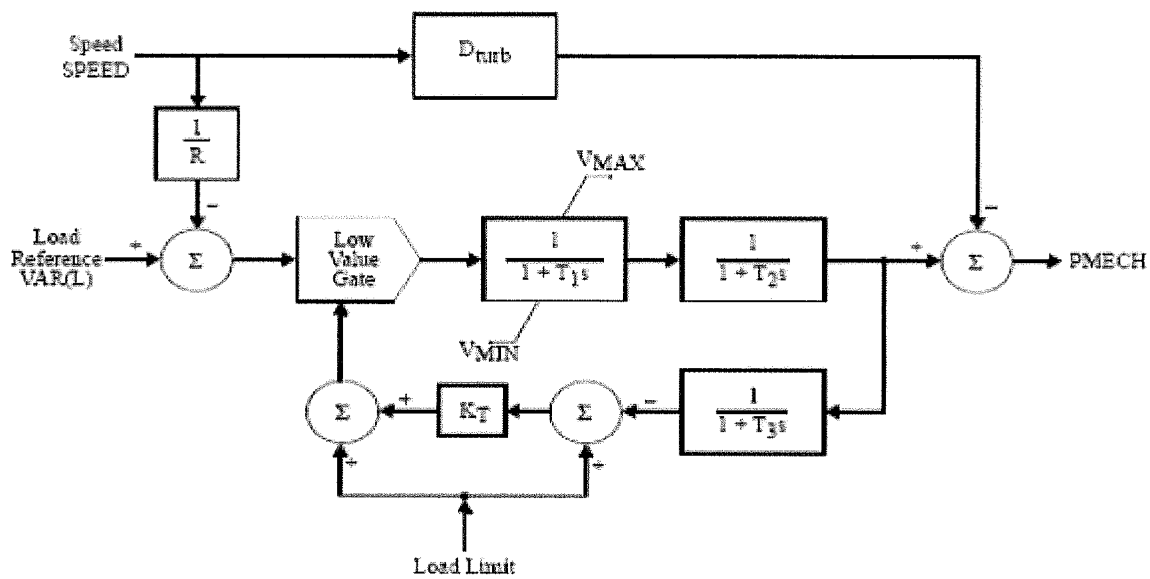
Reviewed by: Print:	Sign:	Date:

APPENDIX F
Fermi 2 Peaker Parameters

TURBINE GOVERNOR MODEL

GAST Gas turbine-governor model

R	Speed droop
T1	>0, Governor mechanism time constant, second
T2	>0, turbine power time constant, second
T3	>0, turbine exhaust temperature time constant, second
AT	Ambient temperature load limit
KT	Temperature limiter gain
VMAX	Maximum turbine power , pu of mvacap
VMIN	Minimum turbine power , pu of mvacap
DT	Turbine damping coefficient, pu



APPENDIX F
Fermi 2 Peaker Parameters

DYNAMIC MODELS AND DATA IN AREA 219 ITC

Generator

GENROU	BUS NAME	EXPANDED BUS NAME	UNIT ID	KV	UNIT MVA BASE	T'D0
264558	19ENFPP	ENRICO FERMI 11-1 ~ 11-4	11	13.8	75.296	5.00

T"D0	T'Q0	T"Q0	H	DAMP	XD	XQ	X'D	X'Q	X"D	XL	S(1.0)*	S(1.2)*
0.03	1.00	0.05	6.00	0.0	1.8000	1.7000	0.2700	0.4500	0.2500	0.1900	0.1250	0.3974

Excitation System

EXST1	BUS NAME	EXPANDED BUS NAME	UNIT ID	KV	UNIT MVA BASE	TR
264558	19ENFPP	ENRICO FERMI 11-1 ~ 11-4	11	13.8	75.296	0.0

VIMAX	VIMIN	TC	TB	KA	TA	VRMAX	VRMIN	KC	KF	TF
999.0	-999.0	1.0	10.0	100.0	0.1	5.0	0.0	0.0	0.0	10.0

Turbine Governor

GAST	BUS NAME	EXPANDED BUS NAME	UNIT ID	KV	UNIT MVA BASE	R
264558	19ENFPP	ENRICO FERMI 11-1 ~ 11-4	11	13.8	75.296	0.05

T1	T2	T3	AT	KT	VMAX	VMIN	DT
0.40	0.10	3.00	1.00	2.00	1.00	0.00	0.00

* Modified by Ming Wu in ITC on 09/08/08 based on the reactive power curves provided by DTE.
** The rating MVA should be (4 x 18.824)=75.296 MVA and will change this data on MMWG2009 series cases in 2009

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Reviewed by: Print:	Sign:	Date:

APPENDIX G

EDG Start Time Delay Relay Error

The maximum error associated with the EDG start relays is determined because this value is used to reduce the 13 second LOCA EDG start time to determine the upper time Analytical Limit for the Degraded Voltage LOCA timer setpoint. Although the EDG start timer relay is not in the Tech Spec, for conservatism, the standard methodology from C1-4180 is applied to determine the error associated with this breaker, and the resultant maximum and minimum time delays. In the determination of EDG timer relay error, the ALT for the EDG timer is conservatively increased from its existing ±0.05 seconds to a more realistic ±VA/2.

EDG Start Timer Relays Agastat E7012PB			
Div I Buses 64B & 64C: 1MU62 & 1MV62			
Div II Buses 65E & 65F: 1MW62 & 1MX62	Worst case RHR motor		
	2250 hp		
Time Delay Error and Tolerance		Units	σ
Setpt	4.7	sec	
VAT = 5% of setting (	0.235	sec	3
ALT = 0.05 sec (Cal Proc), change to VAT/2	0.1175	sec	3
Relay Time Calibration Error Calculation			
CX = SQRT(CLI^2 + CLO^2) = CLI_T	0.00068	sec	3
EP = ALT if ALT> CX, otherwise **larger**	**0.118**	sec	3
EP = CX if ALT < CX	0.00068		3
CC = (2/3)*SQRT(2*CX^2 + EP^2)	0.07834	sec	2
LC = SQRT(CC1^2 + CC2^2+ … + CCn^2) = CC	**0.07834**	sec	2
Relay Time Error Calculation			
AK = 2*(VA/σVA)	0.157	sec	2
LAK= AK	**0.157**	sec	2
LD = 0.5%*STPT (assumed)	**0.024**	sec	2
Time Channel Error Calculation			
EAV = (1.645/2)*SQRT(LAK^2 + LC^2)	**0.1441**	sec	1.645
CIEK = (1.645/2)*SQRT(LAK^2 + LC^2 + LD^2)	**0.1454**	sec	1.645
Max setpoint actuation	**4.8454**	sec	
Setpt + ALT	4.8175		
NTSP (increasing)	**4.7000**	sec	
Setpt - ALT	4.5825		
Min Setpoint actuation	**4.5546**	sec	
LOCA Time Limit for Diesel Start	**13.0000**	sec	
Time margin left for DV LOCA Timer (apply as lower ALim for DV LOCA Relay)	**8.1546**	sec	
Reduced by the two 0.09 second delays.	**7.9746**	sec	

Note: All error values are ±

APPENDIX H
Measurement & Test Equipment (M&TE) Error

The error associated with the use of the Measurement and Test Equipment in the calibration of the undervoltage and time delay relays is determined for use in Sections 9.1 and 9.3.

Calibration Equipment (M&TE) Error			
Agilent 34401A Multimeter (Input 8.1.8)			Std Dev
RDG (120 bounds all possible readings)	120	V	
RES (LSD)	0.0001	V	3
RANGE	120	V	
VA = 0.06% of RDG + 0.03% of range	0.10800	V	3
TE (18 to 28 C)	N/A		
CLI = SQRT(VA^2 + RES^2)	**0.10800**	V	3
Digital Timer SST-9203 - for LOV and DV w/ LOCA (Input 8.1.4)			
RDG (9 bounds LOV reading and LOCA reading)	9	sec	
RES (LSD)	0.0001	sec	3
VA = larger of LSD or 0.005% RDG			
0.005% RDG	0.00045	sec	2
CLI = SQRT(VA^2 + RES^2)	**0.00068**	sec	3
Digital Timer SST-9203 - for Degraded Voltage w/o LOCA (Input 8.1.14)			
RDG (bounds maximum non-LOCA readings)	50	sec	
RES (LSD)	0.0001	sec	3
VA = larger of LSD or 0.005% RDG			
0.005% RDG	0.0025	sec	2
CLI	**0.00375**	sec	3

ABB

IB 18.4.7-2
Issue E

INSTRUCTIONS

Single-Phase Voltage Relays

UNDERVOLTAGE RELAYS and OVERVOLTAGE RELAYS

TYPE 27, TYPE 27D, TYPE 27H	Catalog Series 211	Standard Case
TYPE 27, TYPE 27D, TYPE 27H	Catalog Series 411	Test Case
TYPE 59D, TYPE 59H	Catalog Series 211	Standard Case
TYPE 59D, TYPE 59H	Catalog Series 411	Test Case

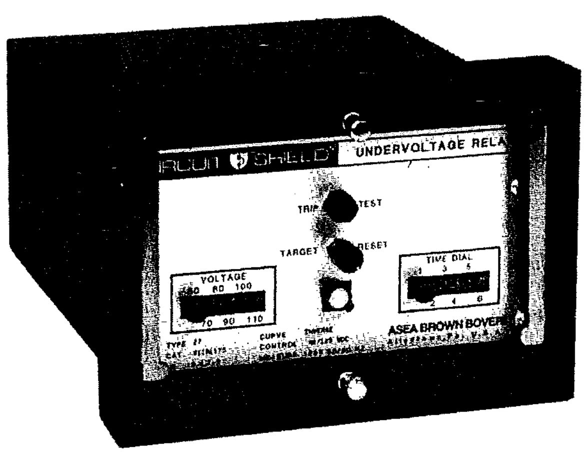

ABB POWER T&D COMPANY INC.
ALLENTOWN, PENNSYLVANIA

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Precautions...................Page 2
Placing Relay into Service....Page 2
Application Data..............Page 3
Testing.......................Page 13

INTRODUCTION

These instructions contain the information required to properly install, operate, and test certain ABB Circuit-Shield™ single-phase undervoltage and overvoltage relays, Types 27, 27D, 27H, 59D, and 59H. See the section on Testing for single-phase voltage relays covered by earlier issues of this instruction book.

The relay is housed in a case suitable for conventional semiflush panel mounting. All connections to the relay are made at the rear of the case and are clearly numbered. Relays of the 411B, 411R, and 411C catalog series are similar to relays of the 211B, 211R, and 211C series. Both series provide the same basic functions and are of totally drawout construction; however, the 411B, 411R, and 411C series relays provide integral test facilities. Also, sequenced disconnects on the 411 series prevent nuisance operation during withdrawal or insertion of the relay if the normally-open contacts are used in the application.

Most settings are made on the front panel of the relay, behind a removable clear plastic cover. The target is reset by means of a pushbutton extending through the relay cover.

PRECAUTIONS

The following precautions should be taken when applying these relays:

1. Incorrect wiring may result in damage. Be sure wiring agrees with the connection diagram for the particular relay before energizing. *Important: connections for the 411 catalog series units are different from the 211 series units.*

2. Apply only the rated control voltage marked on the relay front panel. The proper polarity must be observed when the dc control power connections are made.

3. For relays with dual-rated control voltage, withdraw the relay from the case and check that the movable link on the printed circuit board is in the correct position for the system control voltage.

4. High voltage insulation tests are not recommended. See the section on testing for additional information.

5. The entire circuit assembly of the relay is removable. The unit should insert smoothly. Do not use excessive force.

6. Follow test instructions to verify that the relay is in proper working order.

CAUTION: *since troubleshooting entails working with energized equipment, care should be taken to avoid personal shock. Only competant technicians familiar with good safety practices should service these devices.*

PLACING THE RELAY INTO SERVICE

1. RECEIVING, HANDLING, STORAGE

Upon receipt of the relay (when not included as part of a switchboard) examine for shipping damage. If damage or loss is evident, file a claim at once and promptly notify Asea Brown Boveri. Use normal care in handling to avoid mechanical damage. Keep clean and dry.

2. INSTALLATION

Mounting:
The outline dimensions and panel drilling and cutout information is given in Fig. 1.

Connections:
Internal connections are shown on page 7. Typical external connections are shown in Figure 2. *Important: connections are different for 411B, 411R, and 411C series units compared to 211B, 211R, and 211C units.* Control power must be connected in the proper polarity.

For relays with dual-rated control power: before energizing, withdraw the relay from its case and inspect that the movable link on the lower printed circuit board is in the correct position for the system control voltage. (For units rated 110vdc, the link should be placed in the position marked 125vdc.)

Relays rated for use with 120vac control power have an internal isolation transformer connected to relay terminals 7 and 8. Polarity of the ac control power to these terminals need not be observed.

These relays have metal front panels which are connected through printed circuit board runs and connector wiring to a terminal at the rear of the relay case. The terminal is marked "G". In all applications this terminal should be wired to ground.

3. SETTINGS

PICKUP (VOLTS)
The pickup taps are labelled by the actual value of ac input voltage which will cause the relay to operate. Note: operating voltage values other than the specific values provided by the taps can be obtained by means of an internal adjustment potentiometer. See section on testing for setting procedure.

On these relay models there is no adjustment for the differential between the operate and reset voltage values.

TIME DIAL
The time dial taps are identified as 1,2,3,4,5,6. Refer to the time-voltage characteristic curves in the Application section. Time dial selection is not provided on relays with an Instantaneous operating characteristic.

4. INDICATORS

Target:
An operation target is provided. The target is set electronically when the output contacts transfer. The target will retain its indication on loss of dc control power. In order to reset the target, normal dc control power must be present and a "normal" ac voltage condition must exist; in other words, for an undervoltage relay the voltage must be higher than the set point, and for overvoltage relays, lower.

APPLICATION DATA

The ABB Circuit-Shield™ single-phase voltage relays covered by this instruction book provide a wide range of application including undervoltage protection for motors, over and undervoltage protection for generators, and automatic bus transfer. The relays provide good accuracy and repeatability, and have a flat response over a frequency range of 15 to 400 hertz.

Undervoltage Relay, Type 27, catalog series 211B, 211R, 411B, and 411R:

Typical applications include general purpose undervoltage protection for incoming lines, and initiation of transfer in automatic bus transfer schemes.

Typical external connections are shown in Figures 2.

The relay has an inverse time curve as shown in TVC-605817.

Undervoltage Relay, Type 27D, catalog series 211B, 211R, 411B and 411R:

Typical applications include the initiation of transfer in automatic bus transfer schemes.

Typical external connections are shown in Figure 3.

The Type 27D relay has a definite-time characteristic with 2 ranges available: 0.1-1 second and 1-10 seconds, as shown in TVC-605820 and TVC-605821.

Undervoltage Relays, Type 27H, catalog series 211B, 211R, 411B, 411R:

Typical applications include instantaneous undervoltage detection for bus transfer schemes, and for generator intertie schemes. The low range relay is used as a residual voltage detector in motor bus transfer schemes.

Typical connections are shwon in Figure 3.

The relay has an instantaneous operating time as shown in TVC-605819.

Overvoltage Relays, Type 59H and Type 59D, catalog series 211C and 411C:

These instantaneous and definite time overvoltage relays are companions to the Type 27H and Type 27D undervoltage relays, and offer similar characteristics where overvoltage protection is required.

The time voltage characteristic for the Type 59D is given in TVC-605839. For the Type 59H the maximum operating time above 1.05 times pickup is 16 milliseconds.

Notes on the Use of AC Control Power

In general the use of a station battery to provide a reliable source of tripping and control power is preferred. However, many of the relay types described in this IB are available for use with 120 vac control power. The output contacts may be used in a 120 vac circuit or in a capacitor trip circuit where the capacitor voltage is no more than 170 vdc nominal. (Consult factory if the higher rating is required: "-CAP" catalog suffix.) The control power for these relays should never be taken from a capacitor trip circuit as the voltage is too high and the relay will drain the capacitor in the event of loss of AC supply.

Type 27 and Type 27D Undervoltage Relays used with 120 vac control power in the "self-powered" mode, with both signal and control power taken from the same source, will not maintain their timing characteristics if the voltage drops below approximately 65 volts. The relay will trip immediately. If this characteristic is undesirable for a particular application, the Type 27H instantaneous relay should be used followed by a pneumatic timer with time delay on dropout. A contact from the timer would be used to trip. The timer would be picked up by a contact of the Type 27H under "normal" line conditions. With undervoltage or loss of voltage, the timer would time out and close its contact in the tripping circuit. If the voltage loss were momentary, the timer would allow riding through the loss without tripping. This arrangement thus makes the time delay independent of control power and retains the benefits of accurate voltage sensing provided by the Type 27H relay.

SPECIFICATIONS

Input Circuit:

Rating: 160V, 50/60 Hz. continuous.
300V, 10 seconds.

Burden: 1.2 VA, 1.0 pf at 120 volts.

Taps: available models include:

Types 27, -27D, -27H :	60, 70, 80, 90, 100, 110v
Types 27D, -27H:	30, 35, 40, 45, 50, 55v
	15, 18, 21, 24, 27, 30v
Types 59D, -59H:	100, 110, 120, 130, 140, 150v
	60, 65, 70, 75, 80, 90v

Differential between Operate and Reset Voltages:
Type 27: less than 0.5 percent.
Types 27D, -27H, ITE-59D, -59H: approximately 3 percent.

Operating Time: See Time-Voltage characteristic curves that follow.

Output Circuit:

Each contact @ 125 Vdc: 30 ampere tripping duty.
5 ampere continuous.
0.3 ampere break.

Operating Temperature Range: -30 to +70 deg. C.

Control Power:

Models available for 48/125 vdc @ 0.08 A max.
48/110 vdc @ 0.08 A max.
24/ 32 vdc @ 0.08 A max.
120 vac 50/60 Hz. @ 0.08 A.

Allowable variation:

24vdc	nominal:	19- 29 vdc
32vdc	"	25- 38
48vdc	"	38- 58
110vdc	"	88-125
125vdc	"	100-140
120vac	"	95-135 vac

Tolerances:

Operating Voltage: +/- 5%
Operating Time: +/-10%

These tolerances are based on the printed dial markings. By using the calibration procedures given later in this book, the relay may be set precisely to the desired values of operating voltage and delay with excellent repeatability.

Repeatability: variation in operating voltage for a 10 volt variation in control voltage: 0.2 volt, typical.

variation in operating voltage over the temperature range 20-40 deg C: 0.5 volt, typical.

Dielectric Strength:

1500 vac, 50/60 Hz., all circuits to ground.

Seismic Capability:

More that 6g ZPA biaxial broadband multifrequency vibration without damage or malfunction. (ANSI C37.98-1978)

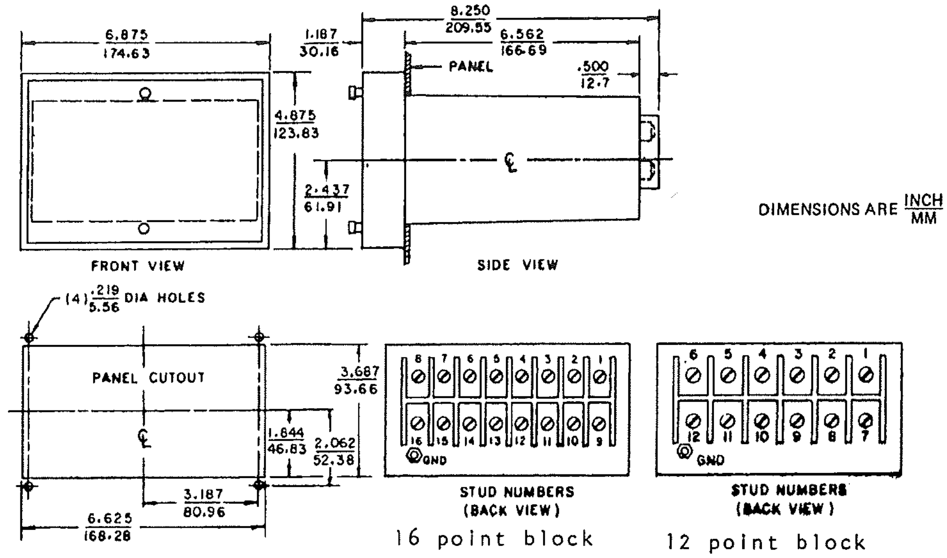


Figure 1: Relay Outline and Drilling

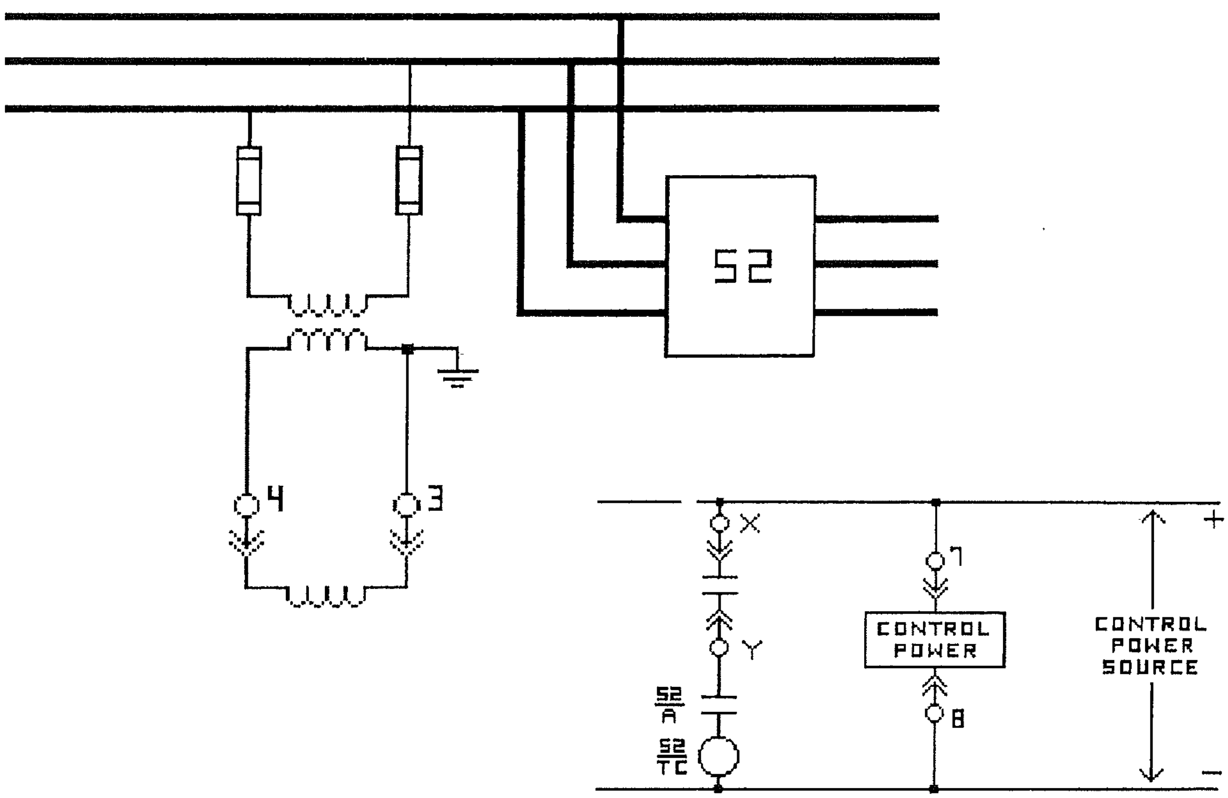


Figure 2: Typical External Connections

Note: Refer to Internal Connection Diagrams and Contact Logic Chart on page 7 to select the specific terminal numbers for the output contact ("X" and "Y") for the particular relay being used. Additionally, a table has been provided on page 15 as a cross-reference.

INTERNAL CONNECTION DIAGRAMS AND OUTPUT CONTACT LOGIC

The following tables and diagrams define the output contact states under all possible conditions of the measured input voltage and the control power supply. "AS SHOWN" means that the contacts are in the state shown on the internal connection diagram for the relay being considered. "TRANSFERRED" means the contacts are in the opposite state to that shown on the internal connection diagram.

FOR DIAGRAM 12D211C

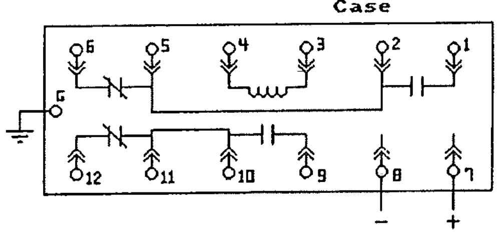
Condition	Contact State		
Cat. Series:	211Rxxx5	211Bxx65	211Cxxx5
Normal Control Power AC Input Voltage Below Setting	As Shown	As Shown	As Shown
Normal Control Power AC Input Voltage Above Setting	Transferred	Transferred	Transferred
No Control Voltage	Transferred	As Shown	As Shown

FOR DIAGRAM 16D210A

Condition	Contact State		
Cat. Series:	411Rxxx5	411Bxx65	411Cxxx5
Normal Control Power AC Input Voltage Below Setting	Transferred	Transferred	As Shown
Normal Control Power AC Input Voltage Above Setting	As Shown	As Shown	Transferred
No Control Voltage	As Shown	Transferred	As Shown

Single-Phase Voltage Relays

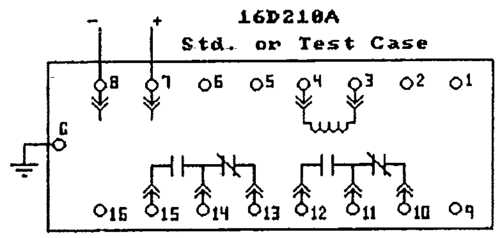
12D211C **Std. Case**



Single-Phase Voltage Relays

16D210A

Std. or Test Case



CHARACTERISTICS OF COMMON UNITS

The following chart gives the basic characteristics of various Circuit-Shield™ single-phase voltage relays from their catalog number breakdown. The relay catalog number will always be found on the front panel of the relay. Do not interpret this chart as a way to specify a relay for purchase as not all combinations are available. For new projects refer to current catalog pages for the latest listing of standard relays, or contact the factory.

2 1 1 R 1 1 7 5

BASIC FUNCTION AND PACKAGE STYLE

211	Single-phase voltage relay in Standard Case
411	Single-phase voltage relay in Test Case

RELAY TYPE AND FUNCTION

B	TYPES 27, -27D, -27H Undervoltage Relay with Type II contact logic
C	TYPES 59, -59D, -59H Overvoltage Relay
D	TYPE 27/59 Under/Overvoltage Relay (obsolete, replaced by 410D series)
E	TYPE 59G Ground Voltage Relay (obsolete, replaced by 210E/410E series)
L	TYPE 27/59 Undervoltage Relay (obsolete, replaced by TYPE 27N)
Q	TYPE 27G 180 Hz. Undervoltage Relay (obsolete, replaced by 410Q)
R	TYPES 27, -27D, -27H Undervoltage Relay with Type I logic

TIME DELAY CHARACTERISTIC

1	Inverse Time Delay Characteristic
4	Definite Time Characteristic 1-10 second range
6	Definite Time Characteristic 0.1-1 second range
0	Instantaneous Characteristic

VOLTAGE TAP RANGE

1	Standard Range: Types 27,-27D,-27H = 60-110v; Types 59,-59D,-59H = 100-150v; Type 59G = 3-18v
2	Low Range: Types 27D,-27H = 30-55v; Types 59D,-59H = 60-90v, Type 27G = 1-12v; Type 59G = 1-6v
5	Special Range: Types 27D,-27H = 15-30v

CONTROL VOLTAGE

6	120 vac
7	48/125 vdc
9	24/ 32 vdc
0	48/110 vdc

OUTPUT CONTACTS

1	2 normally open
5	2 form C

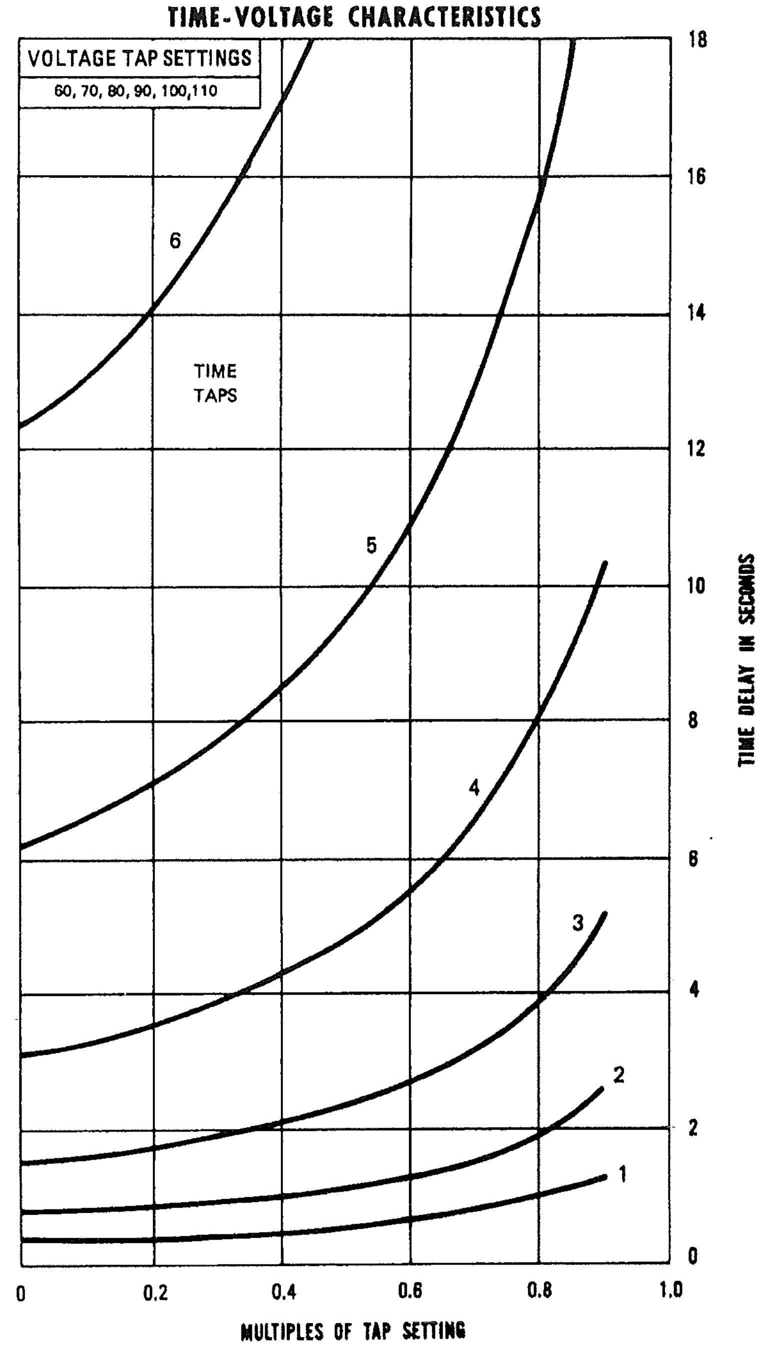


ABB Circuit-Shield™ TYPE 27 UNDERVOLTAGE RELAY

INVERSE (Medium Time)

MAY 1, 1975

TVC-605817

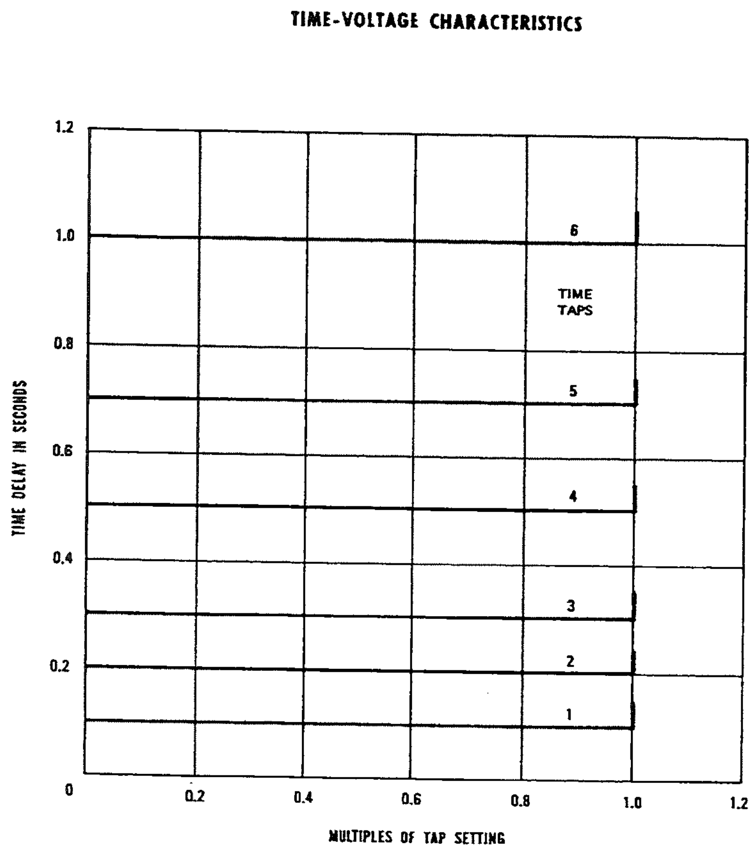


ABB Circuit-Shield™ TYPE 27D UNDERVOLTAGE RELAY
DEFINITE TIME (Short)

Catalog Series 211x6xxx and 411x6xxx

MAY 1, 1975 TVC-605820

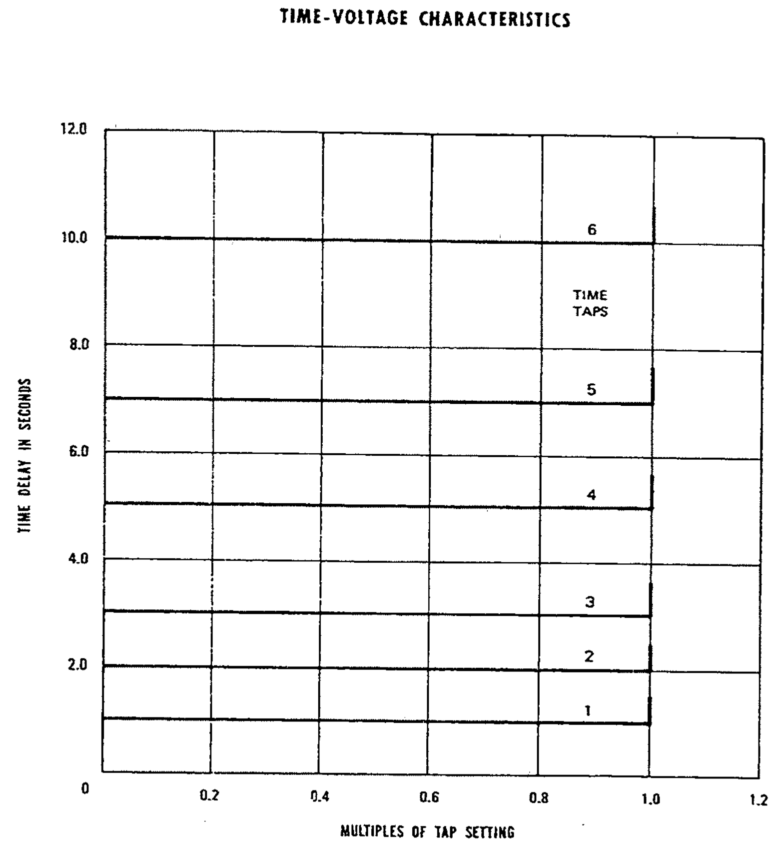


ABB Circuit-Shield™ TYPE 27D UNDERVOLTAGE RELAY
DEFINITE TIME (Medium)

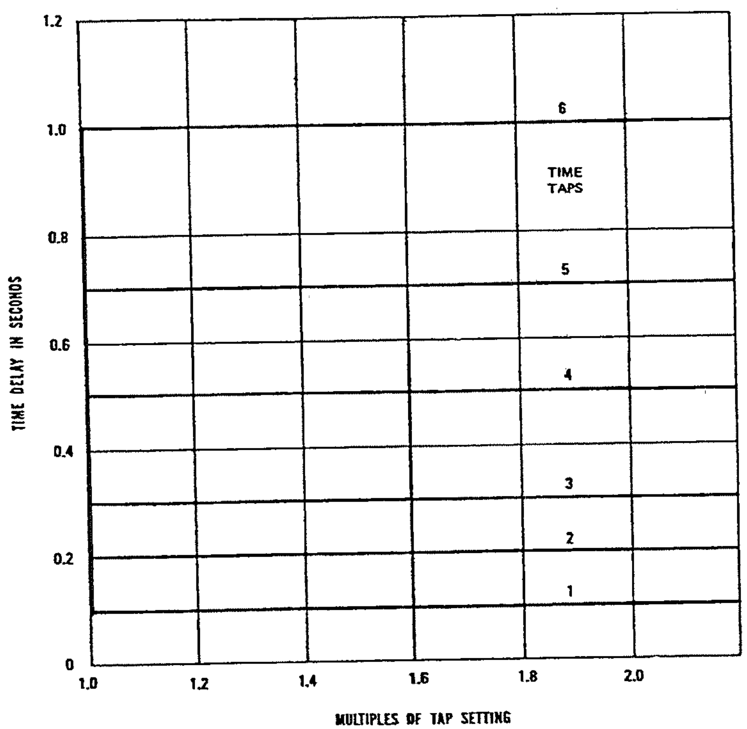
Catalog Series 211x4xxx and 411x4xxx

MAY 1, 1975 TVC-605821

OVERVOLTAGE RELAY

TIME-VOLTAGE CHARACTERISTICS

ABB Circuit-Shield™ TYPE 59D OVERVOLTAGE RELAY
DEFINITE TIME



SHORT TIME Catalog Series 211C6xxx and 411C6xxx
TIME DELAY AS SHOWN

MEDIUM TIME Catalog Series 211C4xxx and 411C4xxx
MULTIPLY TIME DELAY SHOWN BY 10

MAY 1, 1975 | TVC 605839

TIME-VOLTAGE CHARACTERISTICS

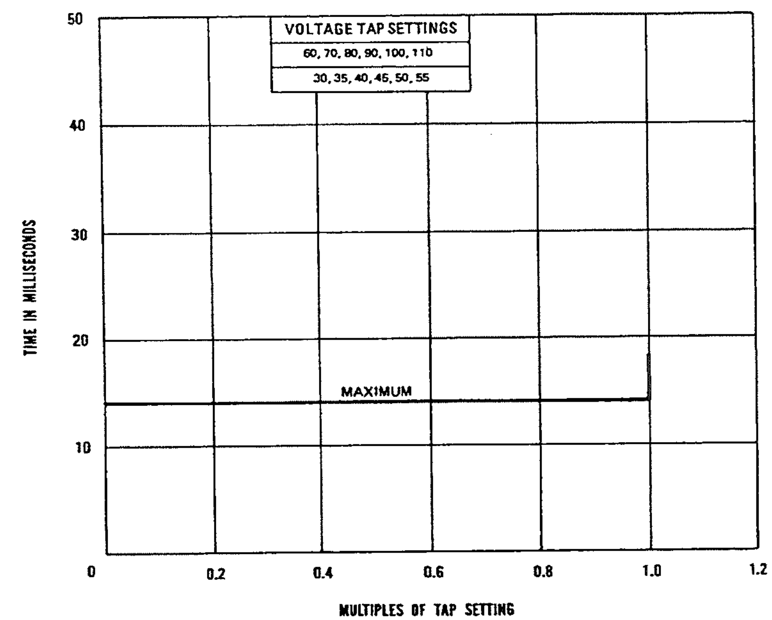


ABB Circuit-Shield™ TYPE 27H UNDERVOLTAGE RELAY
Instantaneous

MAY 1, 1975 | TVC-605819

TESTING

1. MAINTENANCE AND RENEWAL PARTS

No routine maintenance is required on these relays. Follow test instructions to verify that the relay is in proper working order. We recommend that an inoperative relay be returned to the factory for repair; however, a schematic diagram, and in some cases a circuit description, can be provided on request. Renewal parts will be quoted by the factory on request.

There are many earlier versions of these single-phase voltage relays which are now obsolete and have been superseded. If you have a relay which has its front panel stamped with Instruction Book IB 18.4.7-2, but which is not covered by this Issue E of the book, you should request Issue D from the factory. Also see paragraph 6 on obsolete relays.

211 Series Units

Drawout circuit boards of the same catalog number are interchangible. A unit is identified by the catalog number stamped on the front panel and a serial number stamped on the bottom side of the drawout circuit board.

The board is removed by using the metal pull knobs on the front panel. *Removing the board with the unit in service may cause an undesired operation.*

An 18 point extender board (cat 200X0018) is available for use in troubleshooting and calibration of the relay.

411 Series Units

Metal handles provide leverage to withdraw the relay assembly from the case. Removing the unit in an application that uses a normally closed contact will cause an operation. The assembly is identified by the catalog number stamped on the front panel and a serial number stamped on the bottom of the circuit board.

Test connections are readily made to the drawout relay unit by using standard banana plug leads at the rear vertical circuit board. This rear board is marked for easier identification of the connection points.

A test plug assembly, catalog 400X0002 is available for use with the 411 series units. This device plugs into the relay case on the switchboard and allows access to all external circuits wired to the case. See Instruction Book IB 7.7.1.7-8 for details on the use of this device.

2. HIGH POTENTIAL TESTS

High potential tests are not recommended. A hi-pot test was performed at the factory before shipping. If a control wiring insulation test is required, partially withdraw the relay unit from its case sufficient to break the rear connections before applying the test voltage.

3. BUILT-IN TEST FUNCTION

Be sure to take all necessary precautions if tests are run with the main circuit energized.

The built-in test is provided as a convenient functional test of the relay and associated circuit. When you depress the button labelled TRIP, the measuring and timing circuits of the relay are actuated. When the relay times out, the output contacts transfer to trip the circuit breaker or other associated circuitry, and the target is displayed. The test button must be held down continuously until operation is obtained. For the undervoltage relays, the timing is equivilent to that for a complete loss of voltage.

4. ACCEPTANCE TESTS

Follow calibration procedures under paragraph 5. On inverse or definite-time relays, select Time Dial #3. For undervoltage relays check timing by dropping voltage from 120 to 0 volts. For overvoltage relays check timing by increasing voltage to 150% of pickup. Tolerances should be within +/-5% for pickup and +/-10% for timing. Calibration may be adjusted to the final settings required by the application at this time.

5. CALIBRATION

A typical test circuit is shown in Figure 3. Connect the relay to a proper source of control voltage to match its nameplate rating and internal plug setting for dual-rated units. The ac test source should be harmonic-free. Sources using ferro-resonant-transformer regulators should not be used due to high harmonic content.

For relays with time delay, the time-dial tap pin should be placed in position #1 (fastest) when checking pickup and dropout voltages. The voltage should be varied slowly to remove the effect of the time delay from the voltage measurements.

Pickup may be varied between the fixed tap values by adjusting the internal pickup calibration potentiometer. For 211 series units the 18 point extender board provides easier access to the internal pots. Place the voltage tap pin in the nearest value and adjust the internal pot, repeating the test until the desired operating voltage is obtained. If the internal pot has insufficient range, move the tap pin to the next closest value and try again. Similarly the time delay may be adjusted higher or lower than the values shown on the time-voltage curves by means of the internal pot.

The internal calibration pots are identified as follows:

Relay Type	Pickup	Time Delay
Type 27, Type 59	R10	R25 *
Types -27D, -27H Types -59D, -59H	R13	R38

* Note: RT can also be used as a secondary means of adjustment.

6. OBSOLETE UNITS

The chart on page 8 indicates that certain of the 211 and 411 series single-phase voltage relays have been replaced by improved versions. The following gives a quick reference to the instruction books for the newer units. Should you need the instruction book for the earlier units that are nameplated to call for IB 18.4.7-2, request issue D from the factory.

Type 59, Inverse-time Overvoltage Relay:
Catalog series 211C11xx replaced by 210C11x5 and 410C11x5 series, see IB 7.4.1.7-1.

Type 59G, Ground Overvoltage Relay:
Catalog series 211E replaced by 210E and 410E series, see IB 7.4.1.7-9.

Type 27G, Third Harmonic Undervoltage Relay:
Catalog series 211Q replaced by 410Q series, see IB 7.4.1.7-9.

Type 27/59, Under/Overvoltage Relay:
Catalog series 211D replaced by 410D series, see IB 7.4.1.7-1.

Types 27/59A, -27/59D, -27/59H Under/Overvoltage Relay:
Catalog series 211L replaced by Type 27N, catalog series 211T and 411T, see IB 7.4.1.7-7. (Note: the 211L relays were not used for overvoltage protection; they were undervoltage relays with adjustable pickup and dropout voltages.)

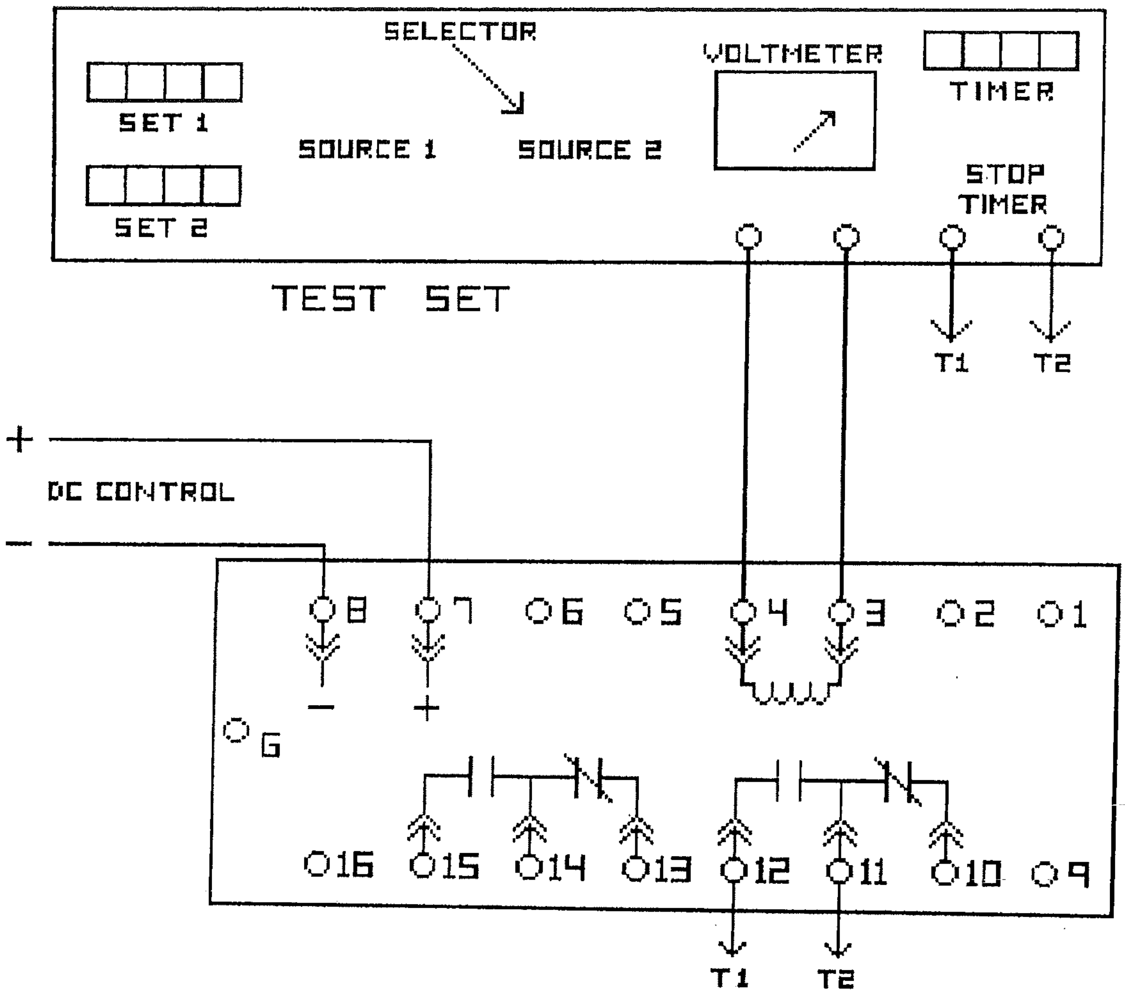


Figure 3: Typical Test Connections

Notes: Test connections shown for a 411C or 411R series unit. For other relays consult the Internal Connection Diagrams and Contact Logic Chart on pg 7 before selecting the output contact to use to stop the timer.

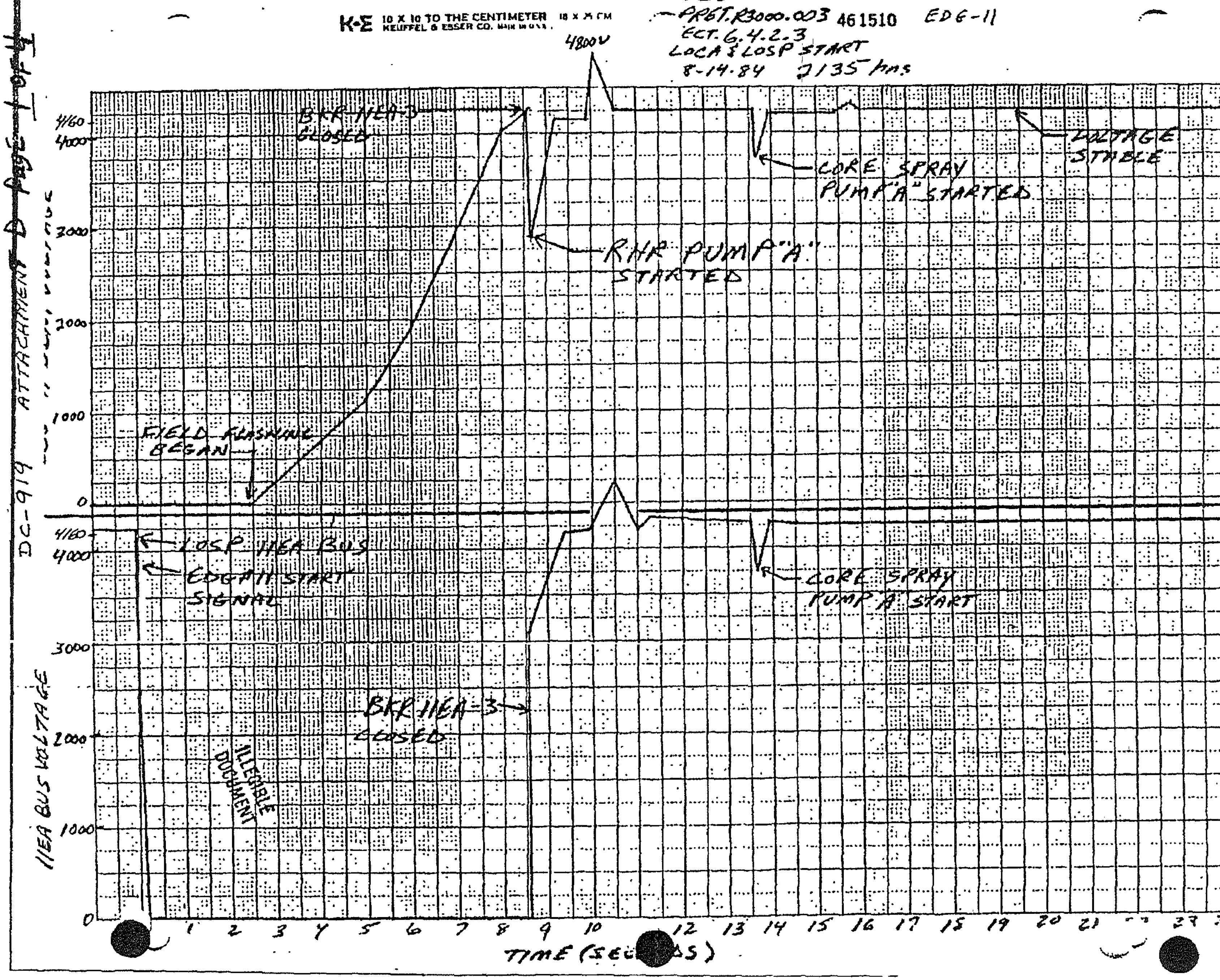
If the test set voltage level adjustment does not have sufficient resolution to properly check and set the pickup voltage, then insert a Variac (adjustable autotransformer) and external voltmeter between the test source and the relay input terminals.

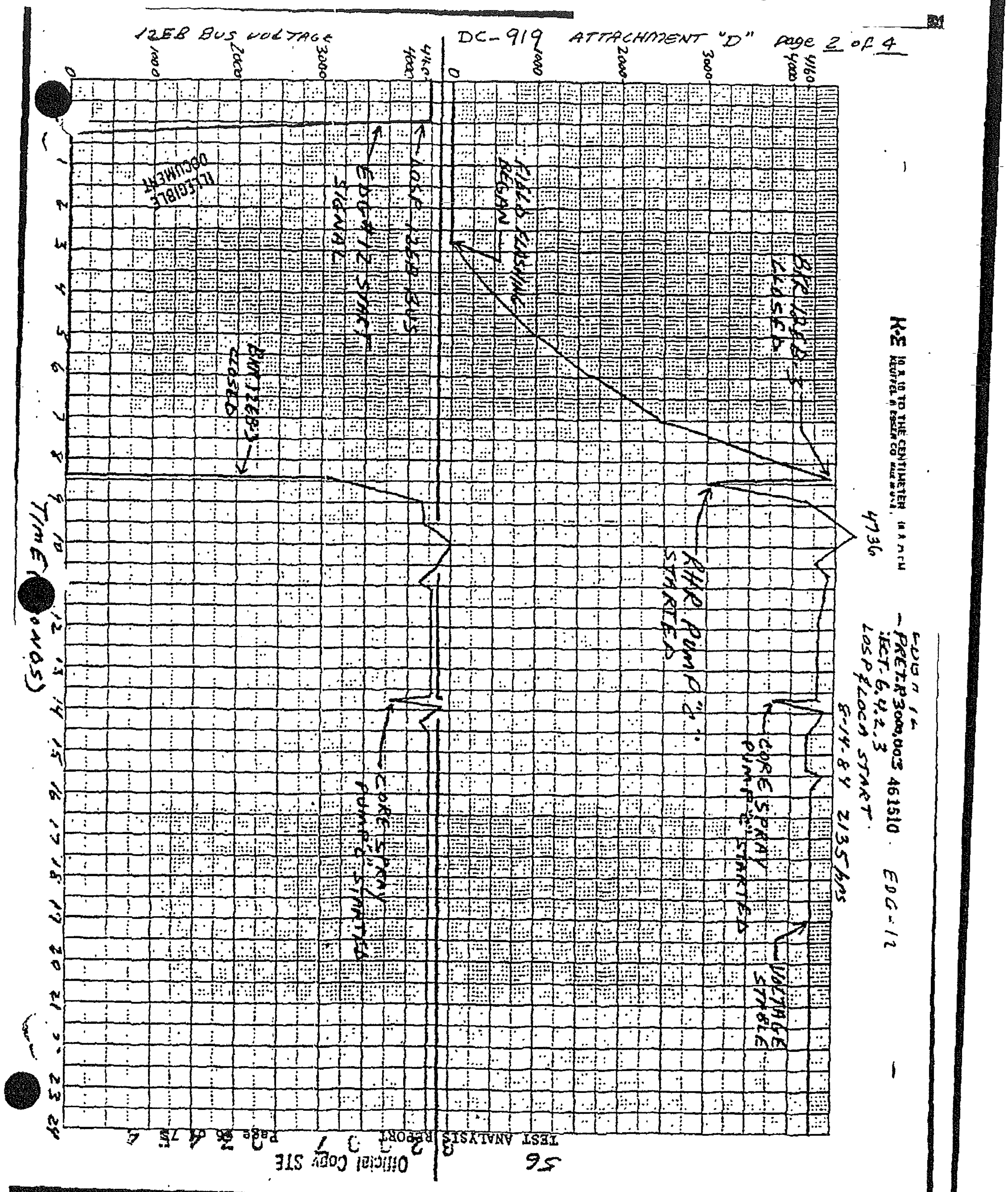
Additional Notes on Figure 2, Typical External Connections:

The note with Figure 2 indicates that the terminal numbers associated with the output contact labelled "X" and "Y" in the diagram must be selected by referring to the internal connection diagram and contact logic chart for the particular relay being considered. As a cross-reference in this selection, the following table lists the terminals associated with the normally-open contacts that close for tripping for the basic relay function. In other words, for an undervoltage relay, the contacts that close for undervoltage, and for an overvoltage relay the contacts that close on overvoltage. An "x" in the catalog number represents any digit ("don't care").

Undervoltage Relays		Contacts that CLOSE on Undervoltage *	
Cat Series	211Rxxx5	5 - 6	11 - 12
	211Bxx65	5 - 6	11 - 12
	411Rxxx5	11 - 12	14 - 15
	411Bxxx5	11 - 12	14 - 15
Overvoltage Relays		**Contacts that CLOSE on overvoltage ***	
Cat Series	211Cxxx5	1 - 2	9 - 10
	411Cxxx5	11 - 12	14 - 15

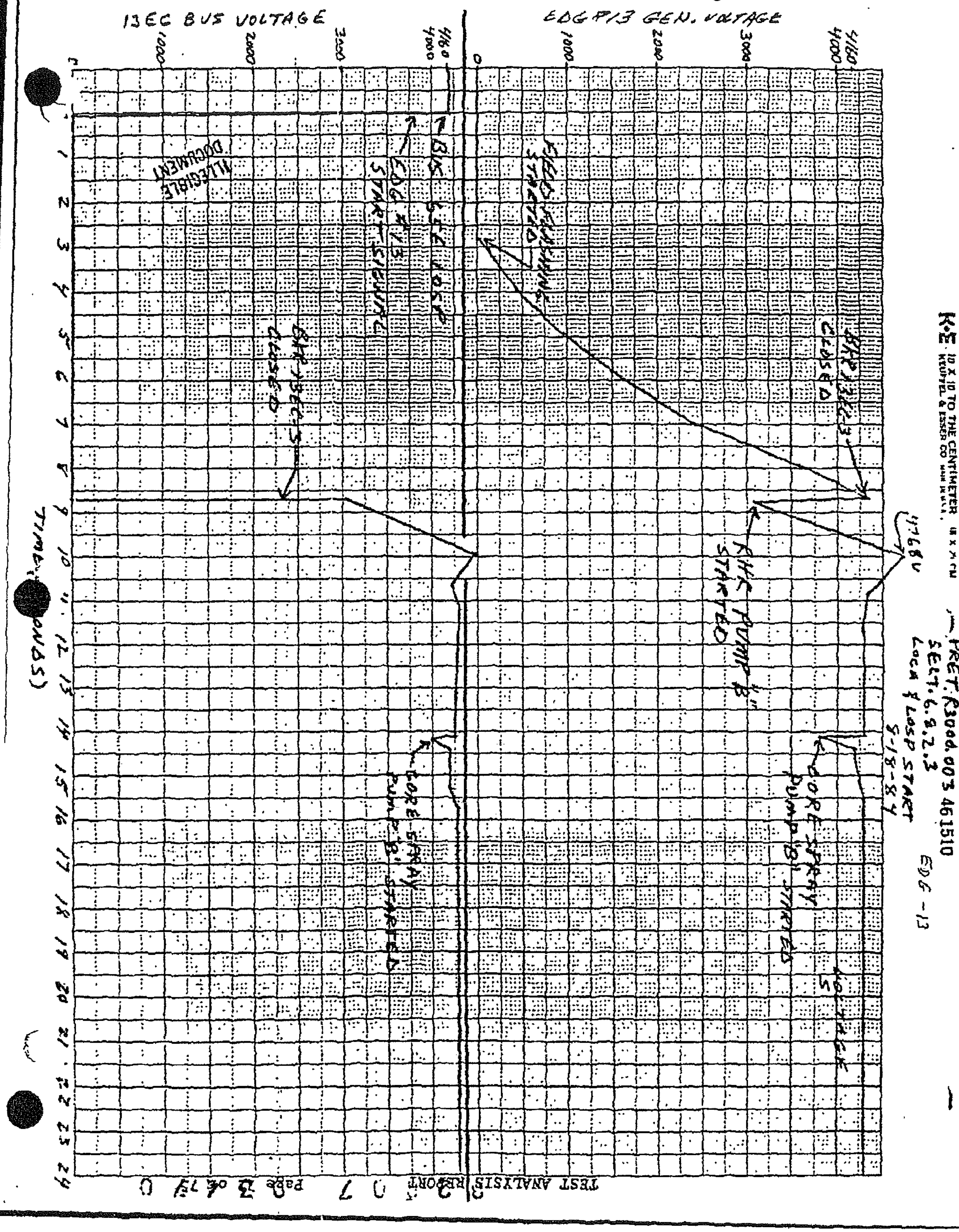
* (Contact closure is after appropriate time delay.)

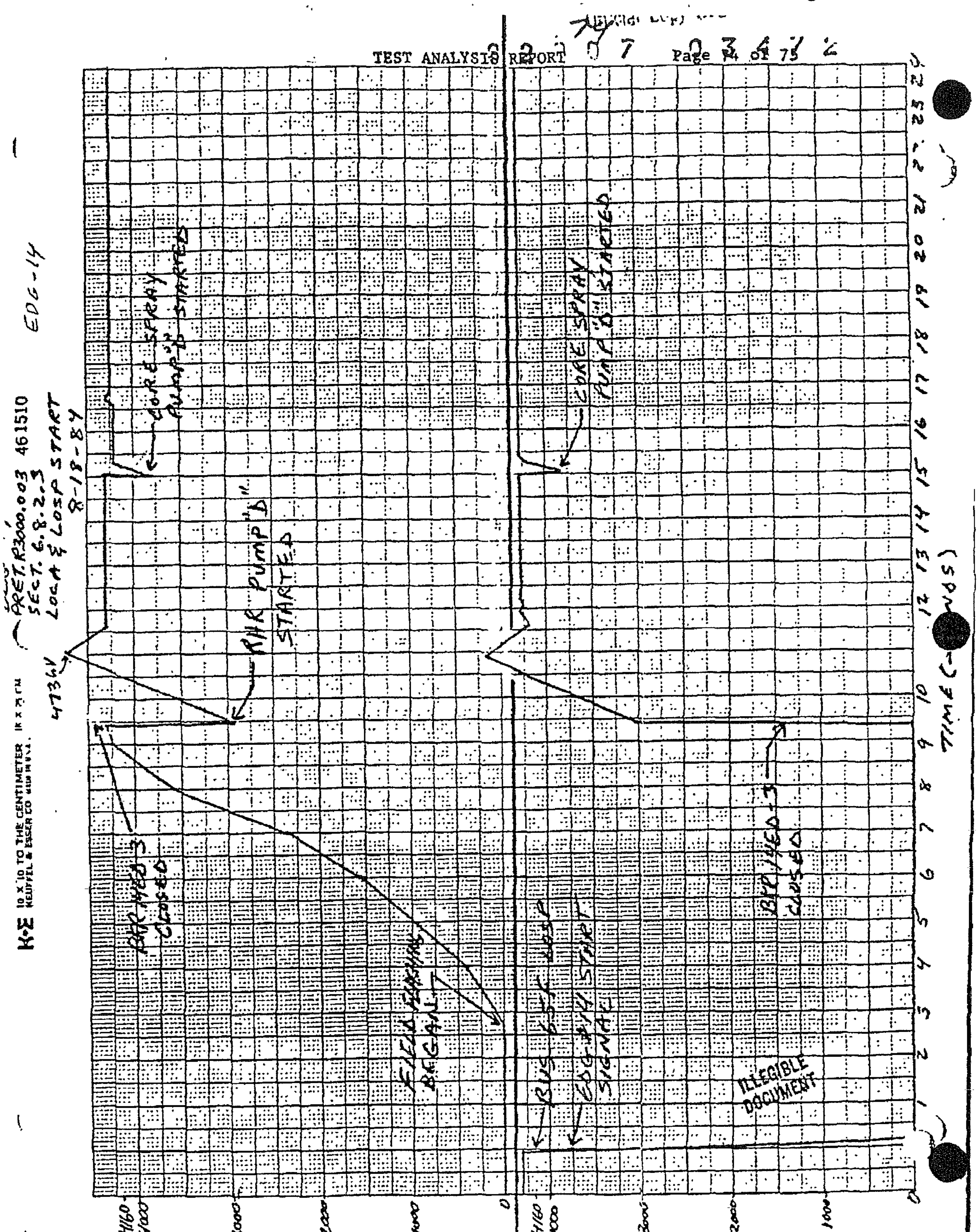

K+E 10 X 10 TO THE CENTIMETER 18 X 25 CM
KEUFFEL & ESSER CO.
PRGT. R3000.003 461510 EDG-11
ECT. 6.4.2.3
LOCA & LOSP START
8-14-84 2135 hrs
4800V
4160
4000
3000
2000
1000
0
BKR 11EA-3 CLOSED
CORE SPRAY PUMP "A" STARTED
VOLTAGE STABLE
RHR PUMP "A" STARTED
FIELD FLASHING BEGAN
LOSP 11EA BUS
EDG A11 START SIGNAL
CORE SPRAY PUMP "A" START
BKR 11EA-3 CLOSED
ILLEGIBLE DOCUMENT
11EA BUS VOLTAGE
1 2 3 4 5 6 7 8 9 10 12 13 14 15 16 17 18 19 20 21 23
TIME (SECONDS)
DC-919 ATTACHMENT D Page 1 of 4


12EB BUS VOLTAGE
DC-919 ATTACHMENT "D" page 2 of 4
TIME (SECONDS)

DC -0919 Vol I DCD 1 Rev. A
Attachment D Page 3 of 4

DC- 919





DC-0919 Attachment "D" page 4 of 4

DC - 919 ATTACHMENT "F"

J.O. No. 15685.08/E121 TEL-CON-NOTE

Copy to: S. Zoma
R.E. Sowers
Job Book

TIME: (A) 0945 (B) 1030 DATE: 18 Oct 82

	NAME	COMPANY
FROM:	G.M. Maher	SWMI
TO:	(A) S. HOATS (B) J FEHLEN	WESTINGHOUSE-BROWN BOVERI (A) (215) 395-7333 (B) (313) 855-0333

TOPIC: (A) Error of ITE-27 RELAYS (B) Error of ITE Potential Transformers

DISCUSSION:	ACTION PARTY
(A) Mr. HOATS advised that the maximum error of the Type ITE-27 relay is < 0.2 Volts on a base voltage of 120V	—
(B) Mr FEHLEN advised that the accuracy of the PT 6 potential transformers used in 480 V switchboards 72 B, C, E & F is Class 0.3 for Burden Designations W, X or Y as defined in USAS C57.13; which on page 27 attached, shows the Limits of Transformer Correction Factors to be 0.997 min to 1.003 MAX. between 0.6 and 1.0 Power Factor. A copy of page 27 was given to S.P. Zoma	—

DC-919 ATTACHMENT "F"
Page 2 of 2

Table 13
Standard Burdens for Potential Transformers

Standard Burdens			Characteristics on 120 Volt Basis			Characteristics on 69.3 Volt Basis		
Designation	Volt-Amperes	Power Factor	Resistance Ohms	Inductance Henrys	Impedance Ohms	Resistance Ohms	Inductance Henrys	Impedance Ohms
W	12.5	0.10	115.2	3.042	1152	38.4	1.014	384
X	25	0.70	403.2	1.092	576	134.4	0.364	192
Y	75	0.85	163.2	0.268	192	54.4	0.0894	64
Z	200	0.85	61.2	0.101	72	20.4	0.0336	24
ZZ	400	0.85	30.6	0.0504	36	10.2	0.0168	12

Table 14
Accuracy Classes and Corresponding Limits of Transformer Correction Factors for Potential Transformers for Metering Service*

Metering Accuracy Classes	Limits of Transformer Correction Factors for Range of 90 to 110 Percent Rated Primary Voltage — Min	Max	Limits of Power Factor (Lag) of Metered Power Load
0.3	0.997	1.003	0.6 - 1.0
0.6	0.994	1.006	0.6 - 1.0
1.2	0.988	1.012	0.6 - 1.0

*See Fig. 8.

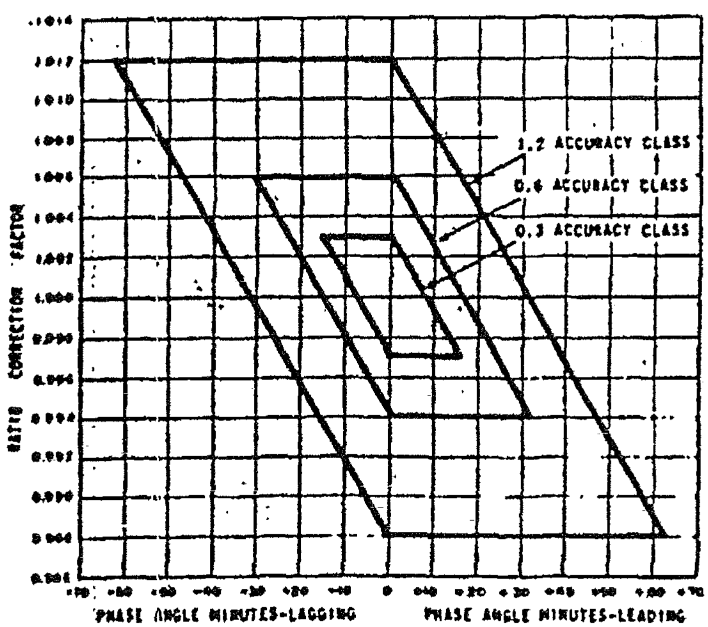
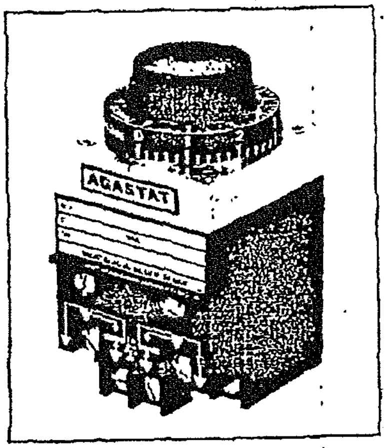


Fig. 8
Limits for Accuracy Classes 0.3, 0.6, and 1.2 for Potential Transformers for Metering Service

series E7000 seismic & radiation-tested timing relays

AGASTAT® Series E7000 Timing Relays are suitable for class 1E service in nuclear power generating stations and comply with the requirements of IEEE Standard 323-1974 and IEEE Standard 344-1975. Testing was also referenced to ANSI/IEEE C37.98.

The present Series E7000 design was evolved over 40 years of continual field use in a wide range of industrial applications. On-Delay, Off-Delay and Four-Pole versions are available for use with a choice of 25 coil voltages, as well as time-calibrated delay adjustments to as long as 60 minutes.



Test Procedure

AGASTAT® Timing Relay Models E7012, E7022, E7014 and E7024 were tested in accordance with the requirements of IEEE STD. 323-1974 *(Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations)*, IEEE STD. 344-1975 (Seismic Qualification for Nuclear Power Generating Stations) and referenced to ANSI/IEEE C37.98 (formerly IEEE Standard 501-1978, Standard for Seismic Testing of Relays). The relays were tested according to parameters which, in practice, should encompass the majority of applications. Documented data apply to timing relays which were mounted on rigid test fixtures. The following descriptions of the tests performed are presented in their actual sequence. Qualification tested for VERTICAL OPERATION ONLY.

Radiation Aging

Relays were subjected to a radiation dosage of 2.0 x 10⁵ Rads, which is considered to exceed adverse plant operating requirements for such areas as auxiliary and control buildings.

Cycling With Load Aging

The radiated units were then subjected to *27,500 operations at accelerated rate*, with one set of contacts loaded to 120VAC, 60Hz at 10 amps; or 125VDC at 1 amp, and the number of mechanical operations exceeding those experienced in actual service.

Temperature Aging

This test subjected the relays to a temperature of 100°C for 42 days, with performance measured before and after thermal stress.

Seismic Aging

Sufficient interactions were performed at levels less than the fragility levels of the devices in order to satisfy the seismic aging requirements of IEEE STD 323-1974 and IEEE STD 344-1975.

Seismic Qualification

Artificially aged relays were subjected to simulated seismic vibration, which verified the ability of the individual device to perform its *required function before, during and/or following* design basis earthquakes. Relays were tested in the non-operating, operating and transitional modes.

Hostile Environment

Since the timing relays are intended for use in auxiliary and control buildings, and not in the reactor containment areas, a hostile environment test was performed in place of the Loss of Coolant Accident (LOCA) test. Relays *were subjected to combination extreme temperature/humidity* plus under/over voltage testing to prove their ability to function under adverse conditions even after having undergone all the previous aging simulation and seismic testing. The devices were operated at minimum and maximum voltage extremes: 85 and 120 *percent of rated voltage for AC* units, and 80 and 120 percent of rated voltage for DC units, with temperatures ranging from 40°F to 172°F at 95 percent relative humidity.

Baseline Performance

In addition to aging tests, a series of baseline tests were conducted before, and immediately after each aging sequence, in the following areas: Pull-in Voltage; Drop-out Voltage; Dielectric Strength at 1650V 60Hz; Insulation Resistance; Operate Time (milliseconds); Recycle Time (milliseconds); *Time Delay (seconds); Repeatability (percent);* Contact Bounce (milliseconds at 28VDC, 1 amp.); Contact Resistance (milliohms at 28VDC, 1 amp.)

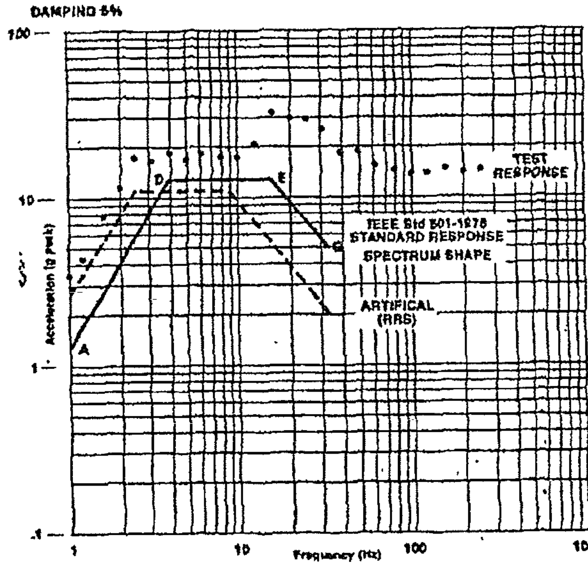
Data were measured and recorded and used for comparison throughout the qualification test program in order to detect any degradation *of performance.*

Figure 1.
Response Spectrum, Transitional Mode

FULL SCALE SHOCK SPECTRUM (g Peak)
MODELS TESTED: E7012AC001
E7012PC001

1.0 10 100 X 1000

DAMPING 5%



The SRS shape (at 5 percent damping), is defined by four points:
- point A = 1.0 Hz and an acceleration equal to *25 percent of the Zero Period Acceleration*
- point D = 4.0 Hz and 250 percent of the ZPA
- point E = 16.0 Hz and 250 percent of the ZPA
- point G = 33.0 Hz and a level equal to the ZPA

SPECIMEN 1 & 3 (E7012 SERIES)
RELAY STATE: TRANSITIONAL MODE (TD X 2)
AXIS (H+V):
TEST RUN NO. 41, 45, 50, 63
COMPOSITE OF FB/V-, SS/V-, SS/V+, FB/V+ X .707
DUE TO 45° INCLINATION OF TEST MACHINE.

For additional shock information request Amerace specification E7012/E7022 or E7014/E7024.

DC-919 ATTACHMENT "G" page 2 of 2

series
E7000

seismic and radiation-tested timing relays

SPECIFICATIONS (See also pp. 3 through 7 for basic operational specifications.)

Environmental Conditions (Qualified Life)

PARAMETER	MIN.	NORMAL	MAX.
Temperature (°F)	40	70-104	156
Humidity (R.H. %)	10	40-60	95
Pressure	—	Atmospheric	—
Radiation (rads)	—	—	2.0 X 10[8] (Gamma)

Operating Conditions (Normal Environment)

NORMAL OPERATING SPECIFICATIONS	WITH DC COILS	WITH AC COILS
Coil Operating Voltage, Nominal (Rated)	As Spec	As Spec
Pull-in (% of rated value)	80% Min.	85% Min.
Drop-out (% of rated value)	*10% Approx.*	*50% Approx.*
Power (Watts at rated value)	8 Approx.	8 Approx.
Relay Operate Time		
Model E7012	N/A	N/A
Model E7022	50 ms. Max.	50 ms Max.
Relay Release (Recycle) Time		
Model E7012	50 ms Max.	50 ms Max.
Model E7022	N/A	N/A
Contact Ratings, Continuous		
(Resistive at 125 vdc)	1.0 amp	1.0 amp
(Resistive at 120 vac, 60 Hz)	10.0 amp	10.0 amp
Insulation Resistance (in megohms at 500 vdc)	500 Min.	500 Min.
Dielectric (vrms, 60 Hz)		
Between Terminals and Ground	*1,500*	*1,500*
Between Non-connected Terminals	1,000	1,000
Repeat Accuracy	± 10%	± 10%
Approximate Weight	Model E7012 and E7022 2.25 lbs. Model E7014 and E7024 2.57 lbs.	Model E7012 and E7022 2.13 lbs. Model E7014 and E7024 2.43 lbs.

(Weight may vary slightly with particular coil voltage.)

Operating Conditions (Abnormal Environment)

ADVERSE OPERATING SPECIFICATIONS	NORMAL	DBE "A"	DBE "B"	DBE "C"	DBE "D"
Temperature (°F)	70-104	40	120	145	156
Humidity (R.H. %)	40-60	10-95	10-95	10-95	10-95
Coil Operating Voltage* (% of Rated)					
Model E7012 (AC)	85-110	85-110	85-110	85-110	85-110
(DC)	80-110	80-110	80-110	80-110	80-110
Model E7022 (AC)	85-110	85-110	85-110	85-110	85-110
(DC)	80-110	80-110	80-110	80-110	80-110

*All coils may be operated on intermittent duty cycles at voltages 10% above listed maximums. (Intermittent Duty = Maximum 50% duty cycle and 30 minutes "ON" time.)

ORDERING INFORMATION

Catalog Number Code

E — 70 — 1 — 2 — A — A — **002

- **E** — Nuclear Safety Related
- **70** — Model Series: AGASTAT† Series 7000 Timing Relay
- **1** — Operation: 1 – On-Delay; 2 – Off-Delay
- **2** — Contact Arrangement: 2 – Double Pole *Double Throw; 4 – Four Pole Double Throw
- **A** — Coil Voltage:
  - AC: A – 120V 60Hz / 110V 50Hz; B – 240V 60Hz / 220V 50Hz; C – 480V 60Hz; D – 550V 60Hz; E – 24V 60Hz; F – 127V 50Hz; G – 240V 50Hz; H – 12V 60Hz; I – 6V 60Hz; J – 208V 60Hz
  - DC: M – 28 VDC; N – 48 VDC; O – 24 VDC; P – 125 VDC; Q – 12 VDC; R – 60 VDC; S – 250 VDC; T – 550 VDC; U – 16 VDC; V – 32 VDC; W – 96 VDC; Y – 6 VDC; Z – 220 VDC
- **A** — Time Range E7012, E7022, E7024: A – .1 to 1 sec.; B – .5 to 5 sec.; C – 1.5 to 15 sec.; D – 5 to 50 sec.; E – 20 to 200 sec.; F – 1 to 10 min.; H – 3 to 30 min.; I – 6 to 60 min.; K – 1 to 300 sec.
  - †E7014: A – .2 to 2 sec.; B – .7 to 7 sec.; C – .2 to 20 sec.; D – 10 to 100 sec.; E – 30 to 300 sec.; F – 1.5 to 15 min.; H – 3 to 30 min.
- ****002** — Configuration Code

† Model E7014 is available with letter-calibrated dials only. *The upper end of the time ranges in this model may be twice the values shown.*

** CONFIGURATION CODE

The Configuration Code is a suffix to the Model Number which provides a means of identification. When a significant product change is introduced, the Configuration Code and specification sheets will be revised. (001 to 002, etc.).

Replacement Schedule

The qualified life of this unit is 25,000 operations or 10 years from the date of manufacture, whichever occurs first.

The date of manufacture can be found in the first four (4) digits of the serial number on the nameplate: XX XX

First two digits indicate the year.

Second two digits indicate the week.

Example: Date code 8014: 80 indicates 1980; 14 indicates the week of April 2 through 8.

MODEL E7012PC002	
COIL 125VDC	*Serial 8014 —*
TIME 1.5 TO 15 SEC.	
L1	L2

Mounting Instructions

The Series E7000 relay MUST BE MOUNTED IN THE VERTICAL POSITION; all perform*ance specifications are valid only when they* are mounted in this manner.

A mounting bracket and screws and lockwashers required to attach it to the relay are *supplied with each unit. Four 8-32 tapped* holes are provided in the rear of the relay for attaching the mounting bracket, or for mounting the relay directly to a panel from the rear.

WARRANTY

This product is warranted against mechanical and electrical defects for a period of two years from date of shipment from factory if it has been installed and used in accordance with factory recommendations. Any field repairs or modifications to the original unit will void this warranty. Amerace Corporation's liability is limited to replacement of parts proved defective in workmanship or materials. (W-AB2)

NOTE: THE BASIC UNIT IS SUBJECTED TO IEEE STD. 323-1974 AND IEEE STD. 344-1975 QUALIFICATION TESTS, PERFORMANCE WITH FACTORY INSTALLED AND/OR CUSTOMER SPECIAL OPTIONS HAS NOT BEEN TESTED.

IB 7.4.1.7-7
Issue E

INSTRUCTIONS

Single Phase Voltage Relays

Type 27N	HIGH ACCURACY UNDERVOLTAGE RELAY
Type 59N	HIGH ACCURACY OVERVOLTAGE RELAY

Type 27N	Catalog Series 211T	• Standard Case
Type 27N	Catalog Series 411 T	• Test Case
Type 59N	Catalog Series 211 U	• Standard Case
Type 59N	Catalog Series 411U	• Test Case

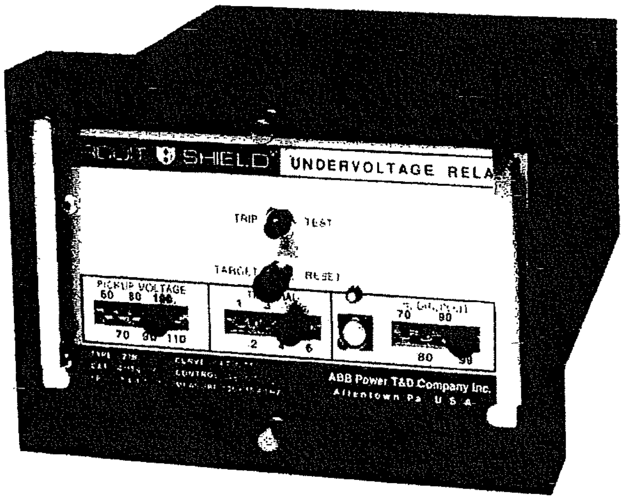


ABB POWER T&D COMPANY INC.
ALLENTOWN, PENNSYLVANIA, USA

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Precautions...................Page 2
Placing Relay into Service....Page 2
Application Data..............Page 4
Testing.......................Page 10

INTRODUCTION

These instructions contain the information required to properly install, operate, and test certain single-phase undervoltage relays type 27N, catalog series 211T and 411T; and overvoltage relays, type 59N, catalog series 211U and 411U.

The relay is housed in a case suitable for conventional semiflush panel mounting. All connections to the relay are made at the rear of the case and are clearly numbered. Relays of the 411T, and 411U catalog series are similar to relays of the 211T, and 211U series. Both series provide the same basic functions and are of totally drawout construction; however, the 411T and 411U series relays provide integral test facilities. Also, sequenced disconnects on the 410 series prevent nuisance operation during withdrawal or insertion of the relay if the normally-open contacts are used in the application.

Basic settings are made on the front panel of the relay, behind a removable clear plastic cover. Additional adjustment is provided by means of calibration potentiometers inside the relay on the circuit board. The target is reset by means of a pushbutton extending through the relay cover.

PRECAUTIONS

The following precautions should be taken when applying these relays:

1. Incorrect wiring may result in damage. Be sure wiring agrees with the connection diagram for the particular relay before energizing.

2. Apply only the rated control voltage marked on the relay front panel. The proper polarity must be observed when the dc control power connections are made.

3. For relays with dual-rated control voltage, withdraw the relay from the case and check that the movable link on the printed circuit board is in the correct position for the system control voltage.

4. High voltage insulation tests are not recommended. See the section on testing for additional information.

5. The entire circuit assembly of the relay is removable. The unit should insert smoothly. Do not use excessive force.

6. Follow test instructions to verify that the relay is in proper working order.

CAUTION: ***since troubleshooting entails working with energized equipment, care should be taken to avoid personal shock. Only competant technicians familiar with good safety practices should service these devices.***

PLACING THE RELAY INTO SERVICE

1. RECEIVING, HANDLING, STORAGE

Upon receipt of the relay (when not included as part of a switchboard) examine for shipping damage. If damage or loss is evident, file a claim at once and promptly notify Asea Brown Boveri. Use normal care in handling to avoid mechanical damage. Keep clean and dry.

2. INSTALLATION

Mounting:
The outline dimensions and panel drilling and cutout information is given in Fig. 1.

Connections:
Typical external connections are shown in Figure 2. Internal connections and contact logic are shown in Figure 3. Control power must be connected in the proper polarity.

For relays with dual-rated control power: before energizing, withdraw the relay from its case and inspect that the movable link on the lower printed circuit board is in the correct position for the system control voltage. (For units rated 110vdc, the link should be placed in the position marked 125vdc.)

These relays have an external resistor wired to terminals 1 and 9 which must be in place for normal operation. The resistor is supplied mounted on the relay.

These relays have metal front panels which are connected through printed circuit board runs and connector wiring to a terminal at the rear of the relay case. The terminal is marked "G". In all applications this terminal should be wired to ground.

3. SETTINGS

PICKUP
The pickup voltage taps identify the voltage level which the relay will cause the output contacts to transfer.

DROPOUT
The dropout voltage taps are identified as a percentage of the pickup voltage. Taps are provided for 70%, 80%, 90%, and 99% of pickup, or, 30%, 40%, 50%, and 60% of pickup.

Note: operating voltage values other than the specific values provided by the taps can be obtained by means of an internal adjustment potentiometer. See section on testing for setting procedure.

TIME DIAL
The time dial taps are identified as 1,2,3,4,5,6. Refer to the time-voltage characteristic curves in the Application section. Time dial selection is not provided on relays with an Instantaneous operating characteristic. The time delay may also be varied from that provided by the fixed tap by using the internal calibration adjustment.

4. OPERATION INDICATORS

The types 27N and 59N provide a target indicator that is electronically actuated at the time the output contacts transfer to the trip condition. The target must be manually reset. The target can be reset only if control power is available, AND if the input voltage to the relay returns to the "normal" condition.

An led indicator is provided for convenience in testing and calibrating the relay and to give operating personnel information on the status of the relay. See Figure 4 for the operation of this indicator.

Units with a "-L" suffix on the catalog number provide a green led to indicate the presence of control power and internal power supply voltage.

APPLICATION DATA

Single-phase undervoltage relays and overvoltage relays are used to provide a wide range of protective functions, including the protection of motors and generators, and to initiate bus transfer. The type 27N undervoltage relay and type 59N overvoltage relay are designed for those applications where exceptional accuracy, repeatability, and long-term stability are required.

Tolerances and repeatability are given in the Ratings section. Remember that the accuracy of the pickup and dropout settings with respect to the printed dial markings is generally not a factor, as these relays are usually calibrated in the field to obtain the particular operating values for the application. At the time of field calibration, the accuracy of the instruments used to set the relays is the important factor. Multiturn internal calibration potentiometers provide means for accurate adjustment of the relay operating points; and allow the difference between pickup and dropout to be set as low as 0.5%.

The relays are supplied with instantaneous operating time, or with definite-time delay characteristic. The definite-time units are offered in four time delay ranges:

0.1-1 second, 1-10 seconds, 2-20 seconds or 10-100 seconds.

An accurate peak detector is used in the types 27N and 59N. Harmonic distortion in the AC waveform can have a noticible effect on the relay operating point and on measuring instruments used to set the relay. An internal harmonic filter is available as an option for those applications where waveform distortion is a factor. The harmonic filter attenuates all harmonics of the 50/60 Hz. input. The relay then basically operates on the fundamental component of the input voltage signal. See figure 5 for the typical filter response curve. To specify the harmonic filter add the suffix "-HF" to the catalog number. Note in the section on ratings that the addition of the harmonic filter does reduce somewhat the repeatability of the relay vs. temperature variation. In applications where waveform distortion is a factor, it may be desirable to operate on the peak voltage. In these cases, the harmonic filter would not be used.

CHARACTERISTICS OF COMMON UNITS

Type	Pickup Range	Dropout Range	Time Delay (see note 1) Pickup	Time Delay (see note 1) Dropout	Catalog Numbers Std Case	Catalog Numbers Test Case
27N	60 - 110 v	70% - 99%	Inst	Inst	211T01x5	411T01x5
			Inst	1 - 10 sec	211T41x5	411T41x5
			Inst	0.1 - 1 sec	211T61x5	411T61x5
	70 - 120 v	70% - 99%	Inst	Inst	211T03x5	411T03x5
			Inst	1 - 10 sec	211T43x5	411T43x5
			Inst	0.1 - 1 sec	211T63x5	411T63x5
	60 - 110 v	30% - 60%	Inst	Inst	211T02x5	411T02x5
			Inst	1 - 10 sec	211T42x5	411T42x5
			Inst	0.1 - 1 sec	211T62x5	411T62x5
59N	100 - 150 v	70% - 99%	Inst	Inst	211U01x5	411U01x5
			1 - 10 s	Inst	211U41x5	411U41x5
			0.1 - 1 s	Inst	211U61x5	411U61x5

IMPORTANT NOTES:

1. Units are available with 2-20 second and 10-100 second definite time delay ranges. These units are identified by catalog numbers that have the digit "5" or "7" directly following the letter "T" in the catalog number; i.e.: catalog numbers of the form 411T5xxx has the 2-20 second time delay range and the form 411T7xxx has the 10-100 second time delay range.

2. Each of the listed catalog numbers for the types 27N and 59N contains an "x" for the control voltage designation. To complete the catalog number, replace the "x" with the proper control voltage code digit:

   48/125 vdc 7
   250 vdc 5
   220 vdc 2
   48/110 vdc 0

3. To specify the addition of the harmonic filter module, add the suffix "-HF". For example: 411T4175-HF. Harmonic filter not available on type 27N with instantaneous delay timing characteristic.

SPECIFICATIONS

Input Circuit: Rating: type 27N 150v maximum continuous.
type 59N 160v maximum continuous.

Burden: less than 0.5 VA at 120 vac.

Frequency: 50/60 Hz.

Taps: available models include:
Type 27N: pickup - 60, 70, 80, 90, 100, 110 volts.
70, 80, 90, 100, 110, 120 volts.
dropout- 60, 70, 80, 90, 99 percent of pickup.
30, 40, 50, 60 percent of pickup.

Type 59N: pickup - 100, 110, 120, 130, 140, 150 volts.
dropout- 60, 70, 80, 90, 99 percent of pickup.

Operating Time: See Time-Voltage characteristic curves that follow.
Instantaneous models: 3 cycles or less.

Reset Time: 27N: less than 2 cycles; 59N: less than 3 cycles.
(Type 27N resets when input voltage goes above pickup setting.)
(Type 59N resets when input voltage goes below dropout setting.)

Output Circuit: Each contact

@ 120 vac	@ 125 vdc	@ 250 vdc	
30 amps.	30 amps.	30 amps.	tripping duty.
5 amps.	5 amps.	5 amps.	continuous.
3 amps.	1 amp.	0.3 amp.	break, resistive.
2 amps.	0.3 amp.	0.1 amp.	break, inductive.

Operating Temperature Range: -30 to +70 deg. C.

Control Power:

Models available for	Allowable variation:	
48/125 vdc @ 0.05 A max.	48 vdc nominal	38- 58 vdc
48/110 vdc @ 0.05 A max.	110 vdc "	88-125 vdc
220 vdc @ 0.05 A max.	125 vdc "	100-140 vdc
250 vdc @ 0.05 A max.	220 vdc "	176-246 vdc
	250 vdc "	200-280 vdc

Tolerances: (without harmonic filter option, after 10 minute warm-up)

Pickup and dropout settings with respect to printed dial markings (factory calibration) = +/- 2%.

Pickup and dropout settings, repeatability at constant temperature and constant control voltage = +/- 0.1%. (see note below)

Pickup and dropout settings, repeatability over "allowable" dc control power range: +/- 0.1%. (see note below)

Pickup and dropout settings, repeatablility over temperature range:
-20 to +55°C +/- 0.4%   -20 to +70°C +/-0.7%
0 to +40°C +/- 0.2%   (see note below)

Note: the three tolerances shown should be considered independent and may be cumulative. Tolerances assume pure sine wave input signal.

Time Delay: Instantaneous models: 3 cycles or less.
Definite time models: +/- 10 percent or +/-20 millisecs. whichever is greater.

Harmonic Filter: (optional) All ratings are the same except:
Pickup and dropout settings, repeatability over temperature range:
0 to +55°C +/- 0.75%   -20 to +70°C +/-1.5%
+10 to +40°C +/- 0.40%

Dielectric Strength: 2000 vac, 50/60 Hz., 60 seconds, all circuits to ground.

Seismic Capability: More than 6g ZPA biaxial broadband multifrequency vibration without damage or malfunction. (ANSI C37.98-1978)

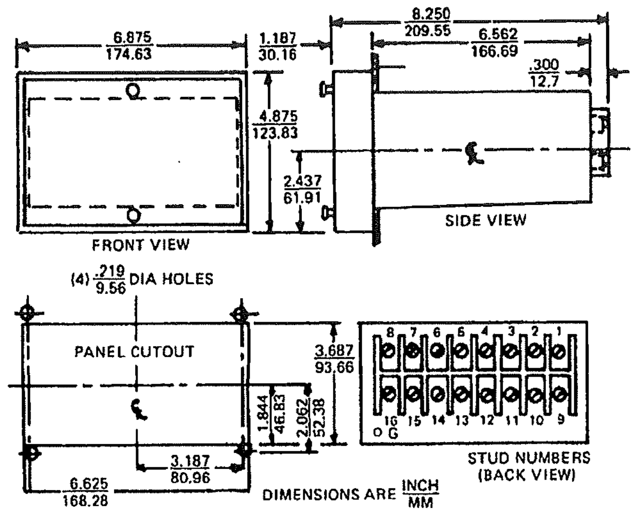


Figure 1: Relay Outline and Panel Drilling

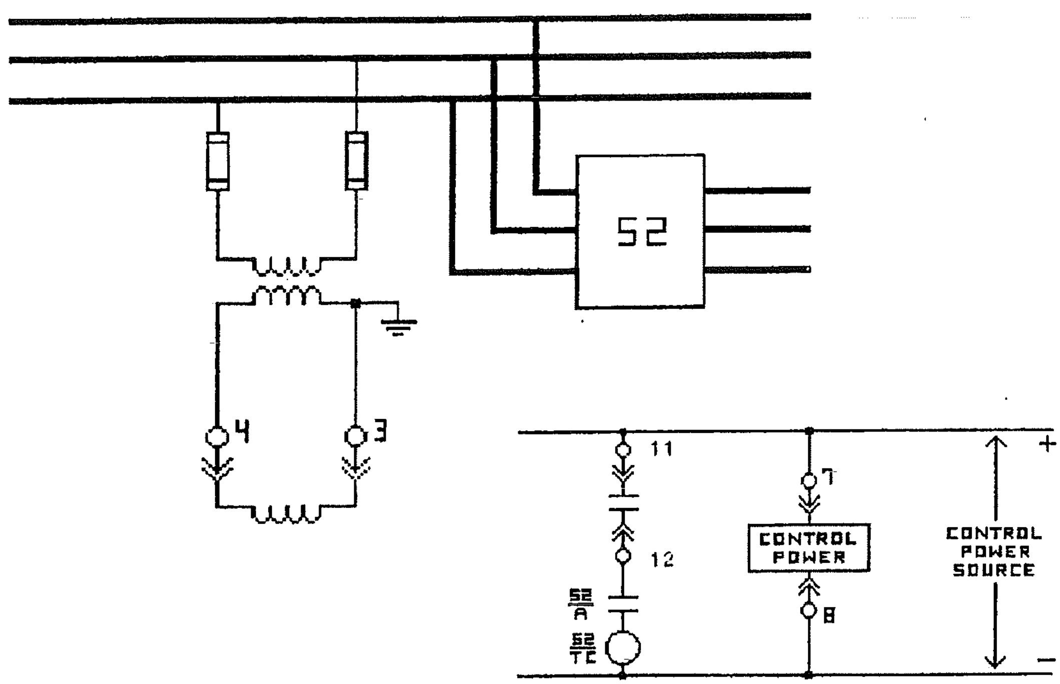
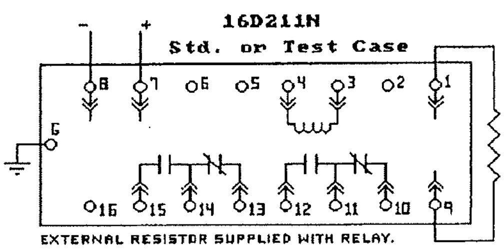


Figure 2: Typical External Connections

Figure 3: INTERNAL CONNECTION DIAGRAM AND OUTPUT CONTACT LOGIC

The following table and diagram define the output contact states under all possible conditions of the measured input voltage and the control power supply. "AS SHOWN" means that the contacts are in the state shown on the internal connection diagram for the relay being considered. "TRANSFERRED" means the contacts are in the opposite state to that shown on the internal connection diagram.

Condition	Contact State	
	Type 27N	Type 59N
Normal Control Power AC Input Voltage Below Setting	Transferred	As Shown
Normal Control Power AC Input Voltage Above Setting	As Shown	Transferred
No Control Voltage	As Shown	As Shown



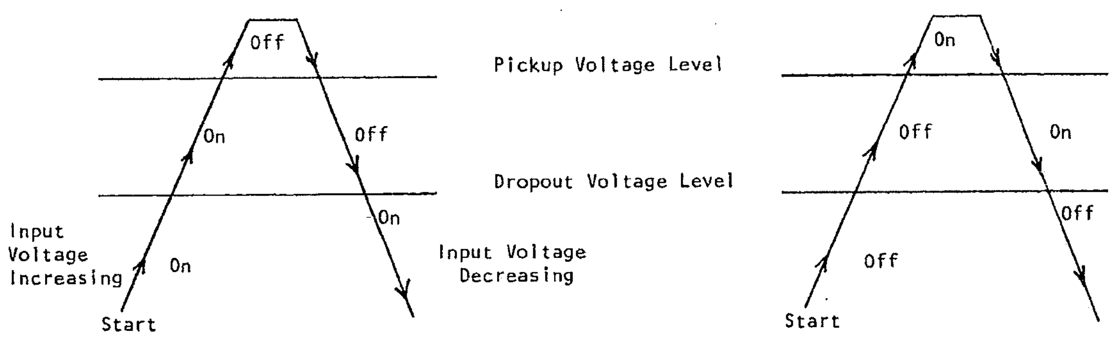
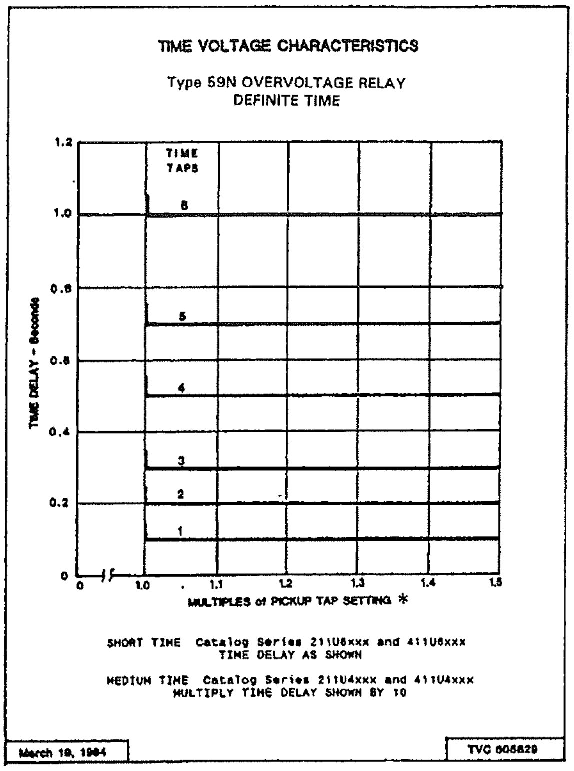
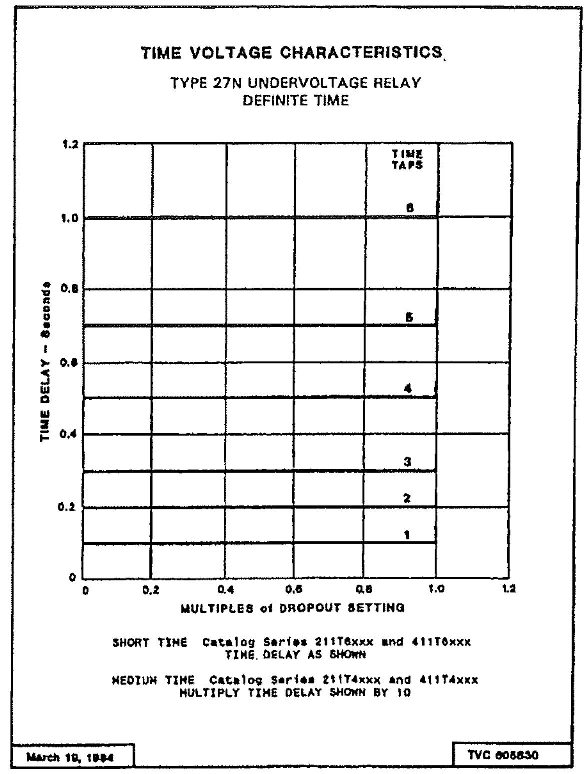


Figure 4a: ITE-27N Operation of Dropout Indicating Light

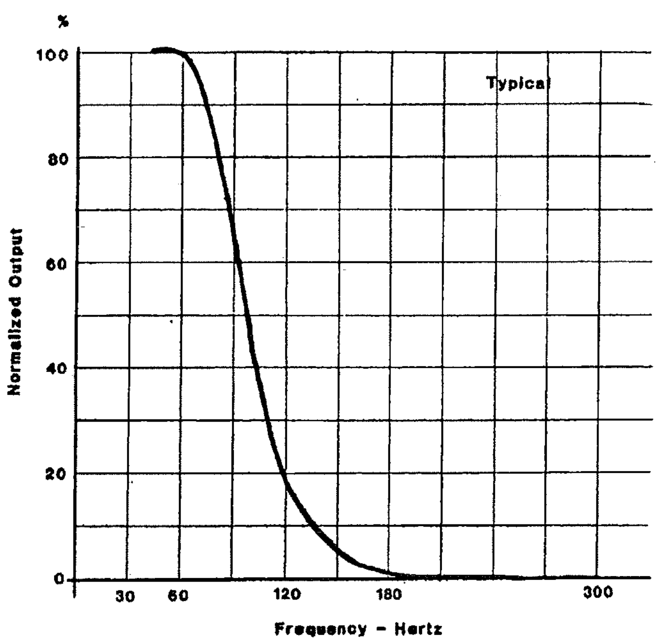
Figure 4b: ITE-59N Operation of Pickup Indicating Light

Figure 4: Operation of Pickup/Dropout Light-Emitting-Diode Indicator





* NOT TO EXCEED INPUT RATING



The time-voltage characteristic is definite-time as shown above. The time-delay values verses time-dial selection for the 2-20 sec. and the 10-100 sec. definite time models are as follows:

Time Dial Tap Pin Position	Nominal Delay Time (sec) 411T5xxx	411T7xxx
# 1	2 seconds	10 seconds
# 2	4	20
# 3	6	30
# 4	10	50
# 5	14	70
# 6	20	100

Figure 5: Normalized Frequency Response - Optional Harmonic Filter Module

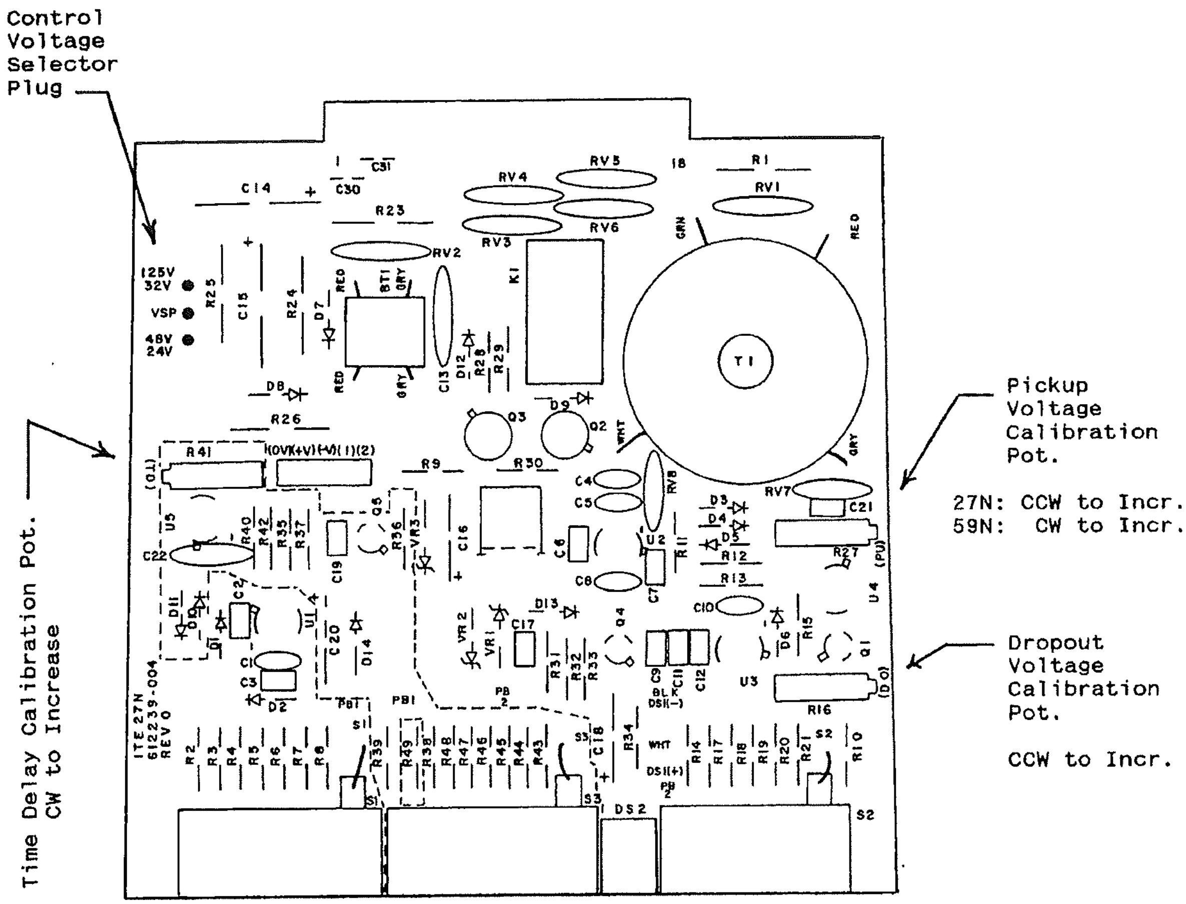


Figure 6: Typical Circuit Board Layouts, types 27N and 59N

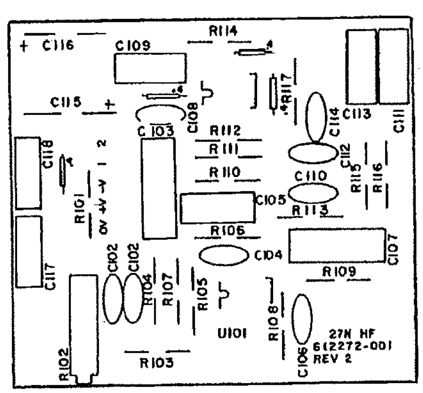


Figure 7: Typical Circuit Board Layout - Harmonic Filter Module

TESTING

1. MAINTENANCE AND RENEWAL PARTS

No routine maintenance is required on these relays. Follow test instructions to verify that the relay is in proper working order. We recommend that an inoperative relay be returned to the factory for repair; however, a circuit description booklet CD7.4.1.7-7 which includes schematic diagrams, can be provided on request. Renewal parts will be quoted by the factory on request.

211 Series Units

Drawout circuit boards of the same catalog number are interchangible. A unit is identified by the catalog number stamped on the front panel and a serial number stamped on the bottom side of the drawout circuit board.

The board is removed by using the metal pull knobs on the front panel. *Removing the board with the unit in service may cause an undesired operation.*

An 18 point extender board (cat 200X0018) is available for use in troubleshooting and calibration of the relay.

411 Series Units

Metal handles provide leverage to withdraw the relay assembly from the case. Removing the unit in an application that uses a normally closed contact will cause an operation. The assembly is identified by the catalog number stamped on the front panel and a serial number stamped on the bottom of the circuit board.

Test connections are readily made to the drawout relay unit by using standard banana plug leads at the rear vertical circuit board. This rear board is marked for easier identification of the connection points.

Important: these relays have an external resistor mounted on rear terminals 1 and 9. In order to test the drawout unit an equivilent resistor must be connected to terminals 1 & 9 on the rear vertical circuit board of the drawout unit. The resistance value must be the same as the resistor used on the relay. A 25 or 50 watt resistor will be sufficient for testing. If no resistor is available, the resistor assembly mounted on the relay case could be removed and used. ***If the resistor from the case is used, be sure to remount it on the case at the conclusion of testing.***

Test Plug:

A test plug assembly, catalog number 400X0002 is available for use with the 410 series units. This device plugs into the relay case on the switchboard and allows access to all external circuits wired to the case. See Instruction Book IB 7.7.1.7-8 for details on the use of this device.

2. HIGH POTENTIAL TESTS

High potential tests are not recommended. A hi-pot test was performed at the factory before shipping. If a control wiring insulation test is required, partially withdraw the relay unit from its case sufficient to break the rear connections before applying the test voltage.

3. BUILT-IN TEST FUNCTION

Be sure to take all necessary precautions if the tests are run with the main circuit energized.

The built-in test is provided as a convenient functional test of the relay and associated circuit. When you depress the button labelled TRIP, the measuring and timing circuits of the relay are actuated. When the relay times out, the output contacts transfer to trip the circuit breaker or other associated circuitry, and the target is displayed. The test button must be held down continuously until operation is obtained.

4. ACCEPTANCE TESTS

Follow the test procedures under paragraph 5. For definite-time units, select Time Dial #3. For the type 27N, check timing by dropping the voltage to 50% of the dropout voltage set (or to zero volts if preferred for simplification of the test). For the type 59N check timing by switching the voltage to 105% of pickup (do not exceed max. input voltage rating.) Tolerances should be within those shown on page 5. If the settings required for the particular application are known, use the procedures in paragraph 5 to make the final adjustments.

5. CALIBRATION TESTS

Test Connections and Test Sources:
Typical test circuit connections are shown in Figure 8. Connect the relay to a proper source of dc control voltage to match its nameplate rating (and internal plug setting for dual-rated units). Generally the types 27N and 59N are used in applications where high accuracy is required. The ac test source must be stable and free of harmonics. A test source with less than 0.3% harmonic distortion, such as a "line-corrector" is recommended. Do not use a voltage source that employs a ferroresonant transformer as the stabilizing and regulating device, as these usually have high harmonic content in their output. The accuracy of the voltage measuring instruments used must also be considered when calibrating these relays.

If the resolution of the ac test source adjustment means is not adequate, the arrangement using two variable transformers shown in Figure 9 to give "coarse" and "fine" adjustments is recommended.

When adjusting the ac test source do not exceed the maximum input voltage rating of the relay.

LED Indicator:
A light emitting diode is provided on the front panel for convenience in determining the pickup and dropout voltages. The action of the indicator depends on the voltage level and the direction of voltage change, and is best explained by referring to Figure 4.

The calibration potentiometers mentioned in the following procedures are of the multi-turn type for excellent resolution and ease of setting. For catalog series 211 units, the 18 point extender board provides easier access to the calibration pots. If desired, the calibration potentiometers can be resealed with a drop of nail polish at the completion of the calibration procedure.

Setting Pickup and Dropout Voltages:
Pickup may be varied between the fixed taps by adjusting the pickup calibration potentiometer R27. Pickup should be set first, with the dropout tap set at 99% (60% on "low dropout units"). Set the pickup tap to the nearest value to the desired setting. The calibration potentiometer has approximately a +/-5% range. Decrease the voltage until dropout occurs, then check pickup by increasing the voltage. Re-adjust and repeat until pickup occurs at precisely the desired voltage.

Potentiometer R16 is provided to adjust dropout. Set the dropout tap to the next lower tap to the desired value. Increase the input voltage to above pickup, and then lower the voltage until dropout occurs. Readjust R16 and repeat until the required setting has been made.

Setting Time Delay:
Similarly, the time delay may be adjusted higher or lower than the values shown on the time-voltage curves by means of the time delay calibration potentiometer R41. On the type 27N, time delay is initiated when the voltage drops from above the pickup value to below the dropout value. On the type 59N, timing is initiated when the voltage increases from below dropout to above the pickup value. Referring to Fig. 4, the relay is "timing out" when the led indicator is lighted.

External Resistor Values: The following resistor values may be used when testing 411 series units. Connect to rear connection points 1 & 9.

Relays rated 48/125 vdc:	4000 ohms;	(-HF models with harmonic filter 4000 ohms)
48/110 vdc:	4000 ohms;	(-HF models with harmonic filter 3200 ohms)
250 vdc:	10000 ohms;	(-HF models with harmonic filter 9000 ohms)
220 vdc:	10000 ohms;	(-HF models with harmonic filter 9000 ohms)

ABB Power T&D Company, Inc.
Protective Relay Division
7036 North Snowdrift Road
Allentown, PA 18106

Issue E (5/96)
Supersedes Issue D

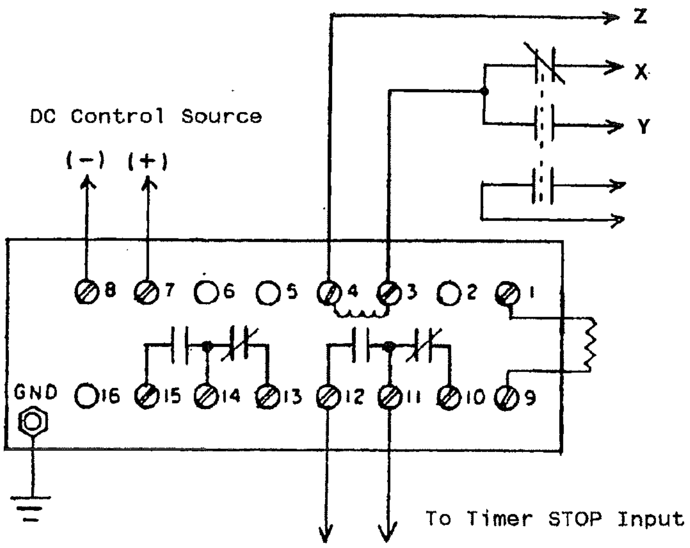


Figure 8: Typical Test Connections

T1, T2	Variable Autotransformers	(1.5 amp rating)
T3	Filament Transformer	(1 amp secondary)
V	Accurate AC Voltmeter	

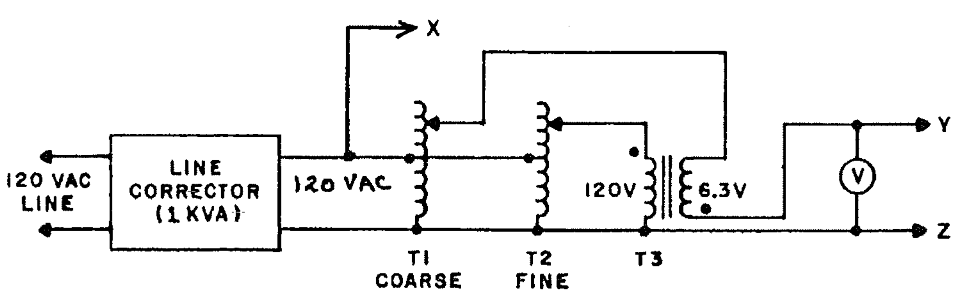


Figure 9: AC Test Source Arrangement

These instructions do not purport to cover all details or variations in equipment, nor to provide for every possible contingency to be met in conjunction with installation, operation, or maintenance. Should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to ABB.

Ugorcak, Patricia

From: Sinclair, Richard [richard_sinclair@tycoelectronics.com]
Sent: Wednesday, June 16, 2010 2:02 PM
To: Ugorcak, Patricia
Subject: RE: Repeatability of Agastat E7012 Series Relays

Hello,

My point is that i didn't say it he did, regarding the 2/3 multiplier. I understand the idea, i didn't say it , that's all.

Regarding the second question, does 5% represent near 100%? In the testing we do at the factory, we can't ship a unit unless we verify that its repeat accuracy is within +/-5%, so by that measure, every relay we ship must have a repeat accuracy of +/-5%. (or we would n't ship it, right?)

thanks!! for asking.

Dick Sinclair
Sr. Product Engineer
Global Aerospace, Defense & Marine
Tyco Electronics Corporation
1396 Charlotte Hwy.
Fairview, NC 28730
Phone 828-338-1109
Fax 828-338-1103
email richard_sinclair@tycoelectronics.com

From: Ugorcak, Patricia [mailto:Patricia.Ugorcak@wgint.com]
Sent: Wednesday, June 16, 2010 2:53 PM
To: Sinclair, Richard
Subject: RE: Repeatability of Agastat E7012 Series Relays

Dick Sinclair,

Thank you for the answer!

What he was trying to say with the 2/3 multiplier is to define how much confidence is associated with the data that support the 5% repeatability. Statistically, if you have a large enough population of test data, then it can be said to represent 99.5% or ~100% of the population, so we can take the stated accuracy in our calcs as a value representing 3 standard deviations. Most accuracy/setpoint calculations determine the error to a 2 standard deviation value, so what he was trying to say was that the stated accuracy of 5% was based on sufficient data to represent a 3 sigma value, so by multiply by 2/3 he would get a 2 standard deviation value.

So the question is, for the 7012 relay with a stated repeatability of 5%, does this represent near 100% of the population?

Patty Ugorcak

Patricia Ugorcak

URS Corporation
(630) 829-2685

patricia.ugorcak@wgint.com

From: Sinclair, Richard [mailto:richard_sinclair@tycoelectronics.com]
Sent: Wednesday, June 16, 2010 12:32 PM
To: Ugorcak, Patricia
Cc: Venturella, John
Subject: RE: Repeatability of Agastat E7012 Series Relays

Hello,

Thank you for contacting us regarding the repeat accuracy of E7000 and 7000 series relays.

I have only one contention with the information you provided and that is the "2/3 multiplier". I am not sure what that means or if I said that. Since i don't know what it means it would be difficult for me to understand how to quote it to Mr. Hoolahan (sic).

Anyway, other than that, the information is correct regarding the comparison of the Agastat 7000s and E7000s.

Thanks!!

Dick Sinclair
Sr. Product Engineer
Global Aerospace, Defense & Marine
Tyco Electronics Corporation
1396 Charlotte Hwy.
Fairview, NC 28730
Phone 828-338-1109
Fax 828-338-1103
email richard_sinclair@tycoelectronics.com

From: Venturella, John
Sent: Wednesday, June 16, 2010 1:06 PM
To: Sinclair, Richard
Subject: FWD: Repeatability of Agastat E7012 Series Relays

The following incident has been forwarded to you:
John Venturella (jventurella@tycoelectronics.com)

Sender's Comment

Contact Information

Email Address: patricia.ugorcak@wgint.com
First Name: Patricia
Last Name: Ugorcak
Type:
Title:
City: Warrenville
State: IL
Zip: 60555
Country:
Phone: 630-829-2685
Fax:
Url:
Country Select: Australia
Type of Customer: OEM (Original Equipment Mfr.)
Legacy Contact ID:
Sample Survey:
Webinar:
iPod:
Gift Card: Yes
Store Contact Data:
Allow Distributor:
Trade Shows:

Employer
URS

Address
4320 Winfield Rd

Phone Number

Source Org Id

Souce Contact Id

Passives Webinar

PluggableIO Webinar

AD&M Whitepaper

DesignCon

Power Webinar

Fortis Webinar

Apec 2010

light+building

Lightfair

Solar 2010

MAE2010

Reference #100616-000351

Summary: Repeatability of Agastat E7012 Series Relays
Rule State: 05 Finished - Updated
Product Level 1: Relays
Category Level 1: Technical / Product Information
Date Created: 06/16/2010 11:26 AM
Last Updated: 06/16/2010 01:05 PM
Status: Unresolved
Assigned: John Venturella
Competitor Part #:
Competitor Name:
Time Stamp:
Language:
Region:
Industry (BU): CIS
Share with SE:

Part Number

URL

Source Org Id

Souce Contact Id

Source Incident Id

Notes for SE

Site Catalyst ID

Discussion Thread

Note (John Venturella) 06/16/2010 01:05 PM

Forward to R. Sinclair

Customer (Patricia Ugorcak) 06/16/2010 11:26 AM

I have a copy of a telephone conversation (file attached) from 2003 with Dick Sinclair pertaining to the E7012 accuracy speicifications. It makes the following points:

- The relay specifications as published are current and valid.
- The specifications are considered bounding values. Use of 2/3 multiplier would be appropriate for 95% confidence interval calculation.
- Series 7000 and Series E7000 are made from identical piece parts.
- The only difference in the manufacturing process between the models is the QA and testing associated with the nuclear qualified E7000 series not the same as 7000 series.
- Repeatability specification for E7000 series (+/-10%) is greater than 7000 series (+/-5%) due to cumulative effects of harsh testing performed on E7000 series relays.
- If a E7000 series and 7000 series relay were operated in the same mild environment, the improved performance characteristics associated with the 7000 series relay would be expected for both relays.
- Due to similarity in design, temperature variation specifications associated with the 7000 series can be applied to the E7000 series.

Is this still true? I need to verify the actula repeatability of the E7012 when not subject harsh environmental effects and seismic events.

This is matter of urgency in support of DTE Energy's Fermi Nuclear 2 Station.

Ugorcak, Patricia

From: Don P. Steltz [don.p.steltz@us.abb.com]
Sent: Tuesday, May 25, 2010 12:48 PM
To: Ugorcak, Patricia
Subject: 27D
Attachments: 27 calibration, guarantee spec.doc

Hi Patricia

We do not have any specific data as to the repeatability for the Type 27D relay, however I am including a note from one of our Engineers that may address your issue. Although this note refers to the Type 27 it does mention the 27D as well. Please keep in mind that the 27D is a general purpose relay and that the 27N may be better suited for a more accurate application.
Hope this helps and let me know if you need any additional information;.

Thanks
Don

(See attached file: 27 calibration, guarantee spec.doc)

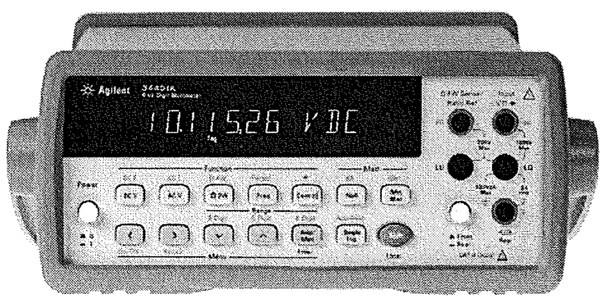
---- Original message ----
I am performing an accuracy calc for the Enrico Fermi 2 Nuclear Power Station for an ABB Type 27D relay, full model number 211R4175. Instruction IB 18.4.7-2 states control power and temperature effects on repeatability, but no specific repeatability effect other than the 5% if using the dial setting. Do you have any information on the base repeatability for the 27D, a number that should be combined with the temperature and control power variation effects to get the total inaccuracy?

Refer to the Specifications (page 5), of the latest version of IB 18.4.7-2.
The pickup/dropout difference for the Type 27 is "less than 0.5 percent" (The 27D and 27H relays are about 3 percent). It should be practical to calibrate the Type 27 to within 0.5 volt of the desired undervoltage operating voltage using the internal calibration pot R10 per the info on pages 13 and 14.
Time Dial # 1 should be used when calibrating the operating voltage. A 15 minute warm-up time should be used with dc control and 120 volts nominal ac voltage applied before making the final calibration adjustment.
Repeatability of the operating point should be within 0.2 volt for short term testing at constant temperature and constant control voltage.
Repeatability for variations in temperature and control voltage is given in the page 5 specifications.
No guarantees are available for long term stability. The Type 27 is a general purpose undervoltage relay and will have reasonable stability - but not the high performance of the Type 27N design. A 2% repeatability value over a 1 year calibration interval would be a conservative assumption (at same temperature and dc control voltage as the original calibration)
The Type 27N is available with Definite-time delay, but not with the Inverse curve of the Type 27.

Agilent 34401A Multimeter

Uncompromising Performance for Benchtop and System Testing

Product Overview



- Measure up to 1000 volts with 6½ digits resolution
- 0.0015% basic dcV accuracy (24 hour)
- 0.06% basic acV accuracy (1 year)
- 3 Hz to 300 kHz ac bandwidth
- 1000 readings/s direct to GPIB

Superior Performance
The Agilent Technologies 34401A multimeter gives you the performance you need for fast, accurate bench and system testing. The 34401A provides a combination of resolution, accuracy and speed that rivals DMMs costing many times more. 6½ digits of resolution, 0.0015% basic 24-hr dcV accuracy and 1,000 readings/s direct to GPIB assure you of results that are accurate, fast, and repeatable.

Use It on Your Benchtop
The 34401A was designed with your bench needs in mind. Functions commonly associated with bench operation, like continuity and diode test, are built in. A Null feature allows you to remove lead resistance and other fixed offsets in your measurements. Other capabilities like min/max/avg readouts and direct dB and dBm measurements make checkout with the 34401A faster and easier.

The 34401A gives you the ability to store up to 512 readings in internal memory. For trouble-shooting, a reading hold feature lets you concentrate on placing your test leads without having to constantly glance at the display.

Use It for Systems Testing
For systems use, the 34401A gives you faster bus throughput than any other DMM in its class. The 34401A can send up to 1,000 readings/s directly across GPIB in user-friendly ASCII format.

You also get both GPIB and RS-232 interfaces as standard features. Voltmeter Complete and External Trigger signals are provided so you can synchronize to other instruments in your test system. In addition, a TTL output indicates Pass/Fail results when limit testing is used.

To ensure both forward and backward compatibility, the 34401A includes three command languages (SCPI, Agilent 3478A and Fluke 8840A /42A), so you don't have to rewrite your existing test software. An optional rack mount kit is available.

Easy to Use
Commonly accessed attributes, such as functions, ranges, and resolution are selected with a single button press.

Advanced features are available using menu functions that let you optimize the 34401A for your applications.

The included Agilent IntuiLink software allows you to put your captured data to work easily, using PC applications such as Microsoft Excel® or Word® to analyze, interpret, display, print, and document the data you get from the 34401A. You can specify the meter setup and take a single reading or log data to the Excel spreadsheet in specified time intervals. Programmers can use ActiveX components to control the DMM using SCPI commands. To find out more about IntuiLink, visit **www.agilent.com/find/intuilink**

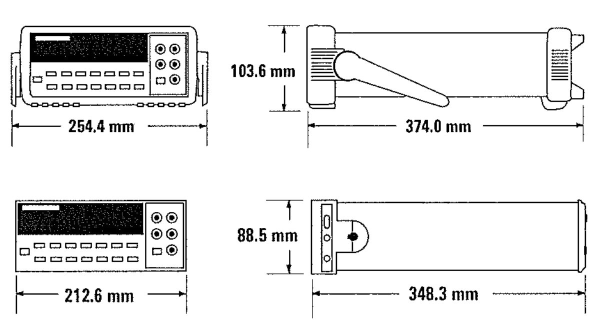
1-Year Warranty
With your 34401A, you get full documentation, a high-quality test lead set, calibration certificate with test data, and a 1-year warranty, all for one low price.

Agilent Technologies

Accuracy Specifications ± (% of reading + % of range)[1]

Function	Range[3]	Frequency, etc.	24 Hour[2] 23°C ±1°C	90 Day 23°C ±5°C	1 Year 23°C ±5°C	Temperature Coefficient 0°C to -18°C 28°C to -55°C
DC voltage	100.0000 mV		0.0030 + 0.0030	0.0040 + 0.0035	0.0050 + 0.0035	0.0005 + 0.0005
	1.000000 V		0.0020 + 0.0006	0.0030 + 0.0007	0.0040 + 0.0007	0.0005 + 0.0001
	10.00000 V		**0.0015 + 0.0004**	**0.0020 + 0.0005**	**0.0035 + 0.0005**	**0.0005 + 0.0001**
	100.0000 V		0.0020 + 0.0006	0.0035 + 0.0006	0.0045 + 0.0006	0.0005 + 0.0001
	1000.000 V		0.0020 + 0.0006	0.0035 + 0.0010	0.0045 + 0.0010	0.0005 + 0.0001
True rms AC voltage[4]	100.0000 mV	3 Hz – 5 Hz	1.00 + 0.03	1.00 + 0.04	1.00 + 0.04	0.100 + 0.004
		5 Hz – 10 Hz	0.35 + 0.03	0.35 + 0.04	0.35 + 0.04	0.035 + 0.004
		10 Hz – 20 kHz	0.04 + 0.03	0.05 + 0.04	0.06 + 0.04	0.005 + 0.004
		20 kHz – 50 kHz	0.10 + 0.05	0.11 + 0.05	0.12 + 0.04	0.011 + 0.005
		50 kHz – 100 kHz	0.55 + 0.08	0.60 + 0.08	0.60 + 0.08	0.060 + 0.008
		100 kHz – 300 kHz[6]	4.00 + 0.50	4.00 + 0.50	4.00 + 0.50	0.20 + 0.02
	1.000000 V to 750.000 V	3 Hz – 5 Hz	1.00 + 0.02	1.00 + 0.03	1.00 + 0.03	0.100 + 0.003
		5 Hz –10 Hz	0.35 + 0.02	0.35 + 0.03	0.35 + 0.03	0.035 + 0.003
		10 Hz – 20 kHz	**0.04 + 0.02**	**0.05 + 0.03**	**0.06 + 0.03**	**0.005 + 0.003**
		20 kHz – 50 kHz	0.10 + 0.04	0.11 + 0.05	0.12 + 0.04	0.011 + 0.005
		50 kHz – 100 kHz[5]	0.55 + 0.08	0.60 + 0.08	0.60 + 0.08	0.060 + 0.008
		100 kHz – 300 kHz[6]	4.00 + 0.50	4.00 + 0.50	4.00 + 0.50	0.20 + 0.02
Resistance[7]	100.0000 Ω	1 mA Current Source	0.0030 + 0.0030	0.008 + 0.004	0.010 + 0.004	0.0006 + 0.0005
	1.000000 kΩ	1 mA	0.0020 + 0.0005	0.008 + 0.001	0.010 + 0.001	0.0006 + 0.0001
	10.00000 kΩ	100 µA	**0.0020 + 0.0005**	**0.008 + 0.001**	**0.010 + 0.001**	**0.0006 + 0.0001**
	100.0000 kΩ	10 µA	0.0020 + 0.0005	0.008 + 0.001	0.010 + 0.001	0.0006 + 0.0001
	1.000000 MΩ	5.0 µA	0.002 + 0.001	0.008 + 0.001	0.010 + 0.001	0.0010 + 0.0002
	10.00000 MΩ	500 nA	0.015 + 0.001	0.020 + 0.001	0.040 + 0.001	0.0030 + 0.0004
	100.0000 MΩ	500 nA || 10 MΩ	0.300 + 0.010	0.800 + 0.010	0.800 + 0.010	0.1500 + 0.0002
DC current	10.00000 mA	< 0.1 V Burden Voltage	0.005 + 0.010	0.030 + 0.020	0.050 + 0.020	0.0020 + 0.0020
	100.0000 mA	< 0.6 V	**0.010 + 0.004**	**0.030 + 0.005**	**0.050 + 0.005**	**0.0020 + 0.0005**
	1.000000 A	< 1.0 V	0.050 + 0.006	0.080 + 0.010	0.100 + 0.010	0.0050 + 0.0010
	3.00000 A	< 2.0 V	0.100 + 0.020	0.120 + 0.020	0.120 + 0.020	0.005 + 0.0020
True rms AC current[4]	**1.000000 A**	3 Hz – 5 Hz	1.00 + 0.04	1.00 + 0.04	1.00 + 0.04	0.100 + 0.006
		5 Hz – 10 Hz	0.30 + 0.04	0.30 + 0.04	0.30 + 0.04	0.035 + 0.006
		10 Hz – 5 kHz	**0.10 + 0.04**	**0.10 + 0.04**	**0.10 + 0.04**	**0.015 + 0.006**
	3.00000 A	3 Hz – 5 Hz	1.10 + 0.06	1.10 + 0.06	1.10 + 0.06	0.100 + 0.006
		5 Hz – 10 Hz	0.35 + 0.06	0.35 + 0.06	0.35 + 0.06	0.035 + 0.006
		10 Hz – 5 kHz	0.15 + 0.06	0.15 + 0.06	0.15 + 0.06	0.015 + 0.006
Frequency or period[8]	100 mV to 750 V	3 Hz – 5 Hz	0.10	0.10	0.10	0.005
		5 Hz – 10 Hz	0.05	0.05	0.05	0.005
		10 Hz – 40 Hz	0.03	0.03	0.03	0.001
		40 Hz – 300 kHz	**0.006**	**0.01**	**0.01**	**0.001**
Continuity	1000.0 Ω	1 mA test current	0.002 + 0.030	0.008 + 0.030	0.010 + 0.030	0.001 + 0.002
Diode test[9]	1.0000 V	1 mA test current	0.002 + 0.010	0.008 + 0.020	0.010 + 0.020	0.001 + 0.002

1 Specifications are for 1 hr warm-up and 6½ digits, slow ac filter.
2 Relative to calibration standards.
3 20% over range on all ranges except 1000 Vdc and 750 Vac ranges.
4 For sinewave input > 5% of range. For inputs from 1% to 5% of range and < 50 kHz, add 0.1% of range additional error.
5 750 V range limited to 100 kHz or 8 x 10^7 Volt-Hz.
6 Typically 30% of reading error at 1 MHz.
7 Specifications are for 4-wire ohms function or 2-wire ohms using Math Null. Without Math Null, add 0.2 Ω additional error in 2-wire ohms function.
8 Input >100 mV. For 10 mV to 100 mV inputs multiply % of reading error x10.
9 Accuracy specifications are for the voltage measured at the input terminals only. 1 mA test current is typical. Variation in the current source will create some variation in the voltage drop across a diode junction.



Measurement Characteristics

DC Voltage

Measurement Method:
Continuously integrating multi-slope III A-D converter

A-D Linearity:
0.0002% of reading + 0.0001% of range

Input Resistance:
10 MΩ or 0.1 V, 1 V, 10 V ranges: Selectable > 10,000 MΩ

100 V, 1000 V ranges: 10 MΩ ±1%

Input Bias Current: < 30 pA at 25°C

Input Protection: 1000 V all ranges

dcV:dcV ratio accuracy:
V_{input} Accuracy + $V_{relevance}$ Accuracy

True RMS AC Voltage

Measurement Method:
AC-coupled true rms-measures the ac component of the input with up to 400 Vdc of bias on any range.

Crest Factor:
Maximum of 5:1 at full scale.

Additional Crest Factor errors (non-sinewave):
Crest factor 1-2: 0.05% of reading
Crest factor 2-3: 0.15% of reading
Crest factor 3-4: 0.30% of reading
Crest factor 4-5: 0.40% of reading

Input Impedance:
1 MΩ ± 2% in parallel with 100 pF

Input Protection: 750 Vrms all ranges

Resistance

Measurement Method:
Selectable 4-wire or 2-wire Ohms.
Current source referenced to LO input.

Maximum Lead Resistance (4-wire):
10% of range per lead for 100 Ω, 1 kΩ ranges.
1 kΩ per lead on all other ranges.

Input Protection:
1000 V all ranges

DC Current

Shunt Resistance:
5 Ω for 10 mA, 100 mA
0.1 Ω for 1 A, 3 A

Input Protection:
Externally accessible 3 A 250 V fuse
Internal 7 A 250 V fuse

True RMS AC Current

Measurement Method:
Directly coupled to the fuse and shunt.
ac coupled true rms measurement (measures the ac component only).

Shunt Resistance:
0.1 Ω for 1 A and 3 A ranges

Input Protection:
Externally accessible 3 A 250 V fuse
Internal 7 A 250 V fuse

Frequency and Period

Measurement Method:
Reciprocal counting technique

Voltage Ranges:
Same as ac voltage function

Gate Time: 1 s, 100 ms, or 10 ms

Continuity/Diode

Response Time:
300 samples/s with audible tone

Continuity Threshold:
Selectable from 1 Ω to 1000 Ω

Measurement Noise Rejection 60 (50) Hz[1]

dc CMRR: 140 dB
ac CMRR: 70 dB

Integration Time and Normal Mode Rejection[2]

100 plc/1.67 s (2 s): 60 dB[3]
10 plc/167 ms (200 ms): 60 dB[3]
1 plc/16.7 ms (20 ms): 60 dB
<1 plc/3 ms or 800 µs): 0 dB

Operating Characteristics[4]

Function	Digits	Reading/s
dcV, dcI, and Resistance	6½	0.6 (0.5)
	6½	6 (5)
	5½	60 (50)
	5½	300
	4½	1000
acV, acI	6½	0.15 slow (3 Hz)
	6½	1 medium (20 Hz)
	6½	10 fast (200 Hz)
	6½	50[5]
Frequency or Period	6½	1
	5½	9.8
	4½	80

Frequency and Period

Configuration rates:	26/s to 50/s
Autorange rate (dc Volts):	>30/s
ASCII readings to RS-232:	55/s
ASCII readings to RS-232:	1000/s
Maximum internal trig rate:	1000/s
Max. ext trig. rate to memory:	1000/s

Triggering and Memory

Reading HOLD Sensitivity:
10%, 1%, 0.1%, or 0.01% of range

Samples/Trigger:
1 to 50,000

Trigger Delay: 0 to 3600 s: 10 µs step size

External Trigger Delay: < 1 ms

External Trigger Jitter: < 500 µs

Memory: 512 readings

Math Functions

NULL, min/max/average, dBm, dB, limit test (with TTL output)

Standard Programming Languages

SCPI (IEEE-488.2), Agilent 3478A, Fluke 8840A/42A

Accessories Included

Test lead kit with probe, alligator and grabber attachments

Operating manual, service manual, test report and power cord

General Specifications

Power Supply:
100 V/120 V/220 V/240 V ±10%

Power Line Frequency:
45 Hz to 66 Hz and 360 Hz to 440 Hz, Automatically sensed at power-on

Power Consumption: 25 VA peak (10 W average)

Operating Environment:
Full accuracy for 0°C to 55°C,
Full accuracy to 80% R.H. at 40°C

Storage Temperature: -40°C to 70°C

Weight: 3.6 kg (8.0 lbs)

Safety: Designed to CSA, UL-1244, IEC-348

RFI and ESD:
MIL-461C, FTZ 1046, FCC

Vibration & Shock:
MIL-T-28800E, Type III, Class 5 (sine only)

Warranty: 1 year

1 For 1 kΩ unbalanced in LO lead, ± 500 V peak maximum.
2 For power line frequency ± 0.1%.
3 For power line frequency ± 0.1% use 40 dB or ± 3% use 30 dB.
4 Reading speeds for 60 Hz and (50 Hz) operation.
5 Maximum useful limit with default settling delays defeated.
6 Speeds are for 4½ digits, delay 0, auto-zero and display OFF.

Ordering Information

Agilent 34401A multimeter accessories included:
Test lead kit with probe, alligator, and grabber attachments, operating manual, service manual, calibration certificate, test report, and power cord.

Options

34401A-1CM
Rack mount kit*
(P/N 5063-9240)

34401A-0B0
DMM without manuals

34401A-A6J
ANSI Z540 compliant calibration

Manual Options

(Please specify one)

34401A-ABA	US English
34401A-ABD	German
34401A-ABE	Spanish
34401A-ABF	French
34401A-ABJ	Japanese
34401A-ABZ	Italian
34401A-AB0	Taiwan Chinese
34401A-AB1	Korean
34401A-AB2	Chinese
34401A-AKT	Russian

Agilent Accessories

11059A	Kelvin probe set
11060A	Surface mount device (SMD) test probes
11062A	Kelvin clip set
34131	Hard transit case
34161A	Accessory pouch
34171B	Input terminal connector (sold in pairs)
34172B	Input calibration short (sold in pairs)
34330A	30 A current shunt
E2308A	5 k thermistor probe

* For racking two side-by-side, order both items below:

Lock link kit (P/N 5061-9694)
Flange kit (P/N 5063-9212)

Remove all doubt

Our repair and calibration services will get your equipment back to you, performing like new, when promised. You will get full value out of your Agilent equipment throughout its lifetime. Your equipment will be serviced by Agilent-trained technicians using the latest factory calibration procedures, automated repair diagnostics and genuine parts. You will always have the utmost confidence in your measurements.

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Agilent Open simplifies the process of connecting and programming test systems to help engineers design, validate and manufacture electronic products. Agilent offers open connectivity for a broad range of system-ready instruments, open industry software, PC-standard I/O and global support, which are combined to more easily integrate test system development.

LXI

www.lxistandard.org
LXI is the LAN-based successor to GPIB, providing faster, more efficient connectivity. Agilent is a founding member of the LXI consortium.

www.agilent.com

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Germany	01805 24 6333** **0.14 €/minute
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Sweden	0200-88 22 55
Switzerland (French)	41 (21) 8113811(Opt 2)
Switzerland (German)	0800 80 53 53 (Opt 1)
United Kingdom	44 (0) 118 9276201

Other European Countries:
www.agilent.com/find/contactus
Revised: October 24, 2007

Product specifications and descriptions in this document subject to change without notice.

Printed in USA, December 20, 2007
5968-0162EN

Agilent Technologies

Agilent 34401A
6 ½ Digit Multimeter

User's Guide

Agilent Technologies

Notices

Manual Part Number

34401-90004

Edition

Seventh Edition. August 2007

Printed in Malaysia

Agilent Technologies, Inc.
3501 Stevens Creek Blvd.
Santa Clara, CA 95052 USA

Software Revision

This guide is valid for the firmware that was installed in the instrument at the time of manufacture. However, upgrading the firmware may add or change product features. For the latest firmware and documentation, go to the product page at:

www.agilent.com/find/34401A

Warranty

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Safety Notices

CAUTION

A **CAUTION** notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in damage to the product or loss of important data. Do not proceed beyond a **CAUTION** notice until the indicated conditions are fully understood and met.

WARNING

A WARNING notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in personal injury or death. Do not proceed beyond a WARNING notice until the indicated conditions are fully understood and met.

Resolution

Resolution is the numeric ratio of the maximum displayed value divided by the minimum displayed value on a selected range. Resolution is often expressed in percent, parts-per-million (ppm), counts, or bits. For example, a 6½-digit multimeter with 20% overrange capability can display a measurement with up to 1,200,000 counts of resolution. This corresponds to about 0.0001% (1 ppm) of full scale, or 21 bits including the sign bit. All four specifications are equivalent.

Accuracy

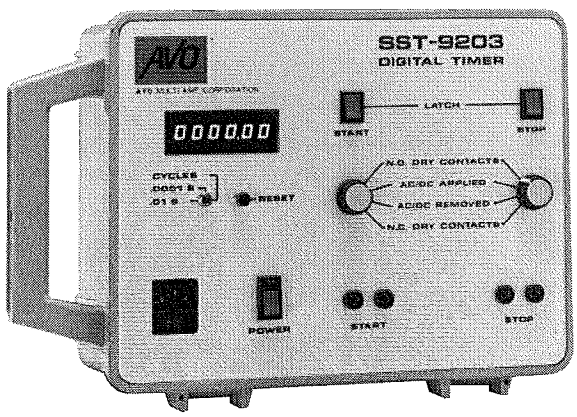
Accuracy is a measure of the "exactness" to which the multimeter's measurement uncertainty can be determined *relative to* the calibration reference used. Absolute accuracy includes the multimeter's relative accuracy specification plus the known error of the calibration reference relative to national standards (such as the U.S. National Institute of Standards and Technology). To be meaningful, the accuracy specifications must be accompanied with the conditions under which they are valid. These conditions should include temperature, humidity, and time.

There is no standard convention among multimeter manufacturers for the confidence limits at which specifications are set. The table below shows the probability of non-conformance for *each specification* with the given assumptions.

Specification Criteria	Probability of Failure
Mean ± 2 sigma	4.5%
Mean ± 3 sigma	0.3%
Mean ± 4 sigma	0.006%

Variations in performance from reading to reading, and instrument to instrument, decrease for increasing number of sigma for a given specification. This means that you can achieve greater actual measurement precision for a specific accuracy specification number. The Agilent 34401A is designed and tested to meet performance better than mean ±4 sigma of the published accuracy specifications.

SST-9203
Solid-State Digital Timer



- **Versatile timing instrument for many utility applications**
- **Rugged design for years of daily field use**
- **±0.0001-second accuracy**
- **Battery or line operated**

DESCRIPTION

The SST-9203 Solid-State Digital Timer combines ruggedness and reliability with state-of-the-art technology to make it an accurate and versatile timing instrument available for utility applications.

APPLICATIONS

Designed specifically to measure the operating time of solid-state and electromechanical relays, circuit breakers, contactors or similar switching devices, Model SST-9203 can be easily used in the field, shop or laboratory.

FEATURES AND BENEFITS

- **Timing versatility:** All necessary start and stop gates are incorporated — applying or removing ac or dc potentials, opening or closing contacts.
- **Accuracy:** ±0.0001 second
- **Resolution:** measures from 0.0001 to 9999.99 seconds **OR** 0.1 to 99999.9 cycles
- **Noise immunity:** Shielding and noise-suppression circuitry ensures reliable operation even in typically "noisy" utility environments such as EHV substations and switchyards.
- **Rugged design:** built tough to provide years of daily field use
- **Built-in rechargeable battery:** Long battery life allows testing in remote locations.

SPECIFICATIONS

Input

115/230 V, 50/60 Hz, 3 VA

Display

0.3-in. (7.6-mm) LED, 6 digits

Battery Capacity

Six hours of continuous usage on a single, full charge. Low battery indication lamp. (Recharge time is twice the time used on battery power. Battery charger is built-in.)

Counter

The specially designed Multi-Amp solid-state digital counter measures the elapsed time of the test in either seconds or cycles. It has extensive shielding and noise-suppression circuitry to ensure accurate and reliable operation under the most demanding field conditions. Incorporating a crystal-controlled oscillator, its accuracy is independent of the power-line frequency.

Ranges (switch-selected)

0.0001 to 99.9999 s
0.01 to 9999.99 s
0.1 to 99999.9 cycles

Start and Stop Gates

Two identical, independent start and stop gate circuits permit simple switch selection of the desired operating modes. The following modes are provided for both the start gate and the stop gate:

Dry Contact Closure (N.O.): Timer starts or stops at the closure of a normally open contact or upon conduction through a semiconductor device, such as an SCR, triac or transistor.

Dry Contact Opens (N.C.): Timer starts or stops at the opening of a normally closed contact or when conduction through a semiconductor device, such as an SCR, triac or transistor is interrupted.

Application of ac or dc Potential (AC/DC APPLIED): In latched mode, timer starts or stops when an ac potential (5 to 300 V rms) or dc potential (6 to 300 V) is applied. In nonlatched mode, timer starts or stops when an ac potential (65 to 300 V rms) or dc potential (6 to 300 V is applied/removed.

Removal of ac or dc Potential (AC/DC REMOVED): Timer starts or stops when an ac potential (65 to 300 V rms) or dc potential (6 to 300 V)is removed.

START Latch

When on, the START latch allows timing to be initiated by any start gate and to be stopped only by the selected stop gate. When off, the START latch allows timing to be initiated by any start gate and to be stopped when that start gate is reversed (such as when timing the closing and opening of a single contact while measuring the trip-free operating time of a circuit breaker).

STOP Latch

When on, the STOP latch allows timing to be stopped at the first operation of any stop gate (thus ignoring contact bounce, for example). When off, the STOP latch allows timing to be stopped by any stop gate, then restarted if the stop gate reverses (provided a start gate is still energized) and then again stopped when the gate again reverses.

Accuracy

The overall accuracy of the instrument, including start and stop gate errors at 25° C is:

Seconds Mode: ± least significant digit (0.0001 or 0.01 depending on seconds range in use) or 0.005% of reading, whichever is greater, when initiated by a dry contact, a dc potential above 5 V or by an ac potential above 115 V*

*AC voltage accuracy decreases at lower voltages and is ±8 ms in worst case (6 V rms applied just following wave-shape peak).

Cycles Mode: ±0.5 cycle when initiated by a dry contact, a dc potential above 5 V or an ac potential above 115 V

Environment

Operating temperature is from 32 to 100° F (0 to 38° C)

Enclosure

The instrument is housed in a high-impact plastic case with lead compartment and equipped with carrying handle and removable cover.

Dimensions

13.5 H x 9.6 W x 9.5 D in. (344 H x 245 W x 242 D mm)

Weight

12 lb (5.5 kg)

ORDERING INFORMATION

Item (Qty)	Cat. No.
Solid-State Digital Timer	SST-9203
Included Accessories	
Line cord (1)	6828
Fuses	
0.25A, 250 V (5)	14692
0.5A, 250 V (5)	14693
Test leads (1 pr)	1282
Pouch (1)	14694
Instruction manual (1)	15027

UK
Archcliffe Road, Dover
CT17 9EN England
T (0) 1 304 502101
F (0) 1 304 207342

UNITED STATES
4271 Bronze Way
Dallas, TX 75237-1018 USA
T 1 800 723 2861
T 1 214 333 3201
F 1 214 331 7399

OTHER TECHNICAL SALES OFFICES
Norristown USA, Toronto CANADA, Mumbai INDIA, Le Raincy FRANCE, Cherrybrook AUSTRALIA, Guadalajara SPAIN and The Kingdom of BAHRAIN.

ISO STATEMENT
Registered to ISO 9001:1994 Reg no. Q 09250
Registered to ISO 14001 Reg no. EMS 61597
SST9203_DS_en_V01
www.megger.com

7000 series

Industrial Electropneumatic Timing Relay

UL File E15631 CSA File LR29186 CE

Note:7032 types and certain models with accessories are not agency approved.

Users should thoroughly review the technical data before selecting a product part number. It is recommended that users also seek out the pertinent approvals files of the agencies/laboratories and review them to confirm the product meets the requirements for a given application.

Consult factory for ordering information.

Design Features

- Available in on-delay, true off-delay, and on/off-delay.
- Timing from 0.1 seconds to 60 minutes, in linear increments.
- Oversize time-calibrated adjustment knobs, serrated with high-resolution markings visible from all angles makes the timer easy to set timers.
- Inherent transient immunity.
- Standard voltages from 6-550VAC and 12-550VDC (special voltages available.)
- Available in 2-pole or 4-pole models.
- Numerous enclosure options: explosion proof, dust tight, watertight, hermetically-sealed, NEMA 1.
- Auxiliary timed and instantaneous switches can be added for greater switching flexibility.
- Many mounting options: Surface mount, Panel mount, Octal plug-in mounting.
- Options: quick-connect terminals, dial stops, and transient protection module.
- Easy-to-reach screw terminals, all on the face of the unit, clearly identified.
- Modular assembly - timing head, coil assembly and switchblock are all individual modules, with switches field-replaceable.

Design & Construction

There are three main components of Series 7000 Timing Relays:

Calibrated Timing Head uses no needle valve, recirculates air under controlled pressure through a variable orifice to provide linearly adjustable timing. Patented design provides instant recycling, easy adjustment and long service life under severe operating conditions.

Precision-Wound Potted Coil module supplies the initial motive force with minimum current drain. Total sealing without external leads eliminates moisture problems, gives maximum insulation value.

Snap-Action Switch Assembly - custom-designed over-center mechanism provides greater contact pressure up to transfer time for positive, no flutter action. Standard switches are DPDT arrangement, with flexible beryllium copper blades and silver-cadmium oxide contacts. Special "timing-duty" design assures positive wiping action, sustained contact pressure and greater heat dissipation during long delay periods.

Each of these subassemblies forms a self-contained module which is then assembled at the factory with the other two to afford a wide choice of operating types, coil voltages, and timing ranges.

The squared design with front terminals and rear mounting permits the grouping of Series 7000 units side-by-side in minimum panel space. Auxiliary switches may be added in the base of the unit, without affecting the overall width or depth.

Operation

Two basic operating types are available.

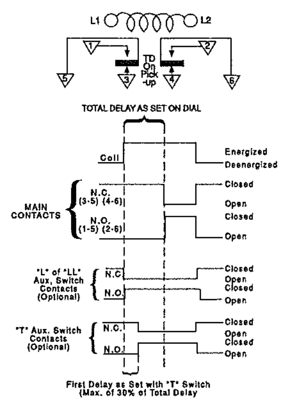
"On-Delay" models provide a delay period on energization, at the end of which the switch transfers the load from one set of contacts to another. De-energizing the unit during the delay period immediately recycles the unit, readying it for another full delay period on re-energization.

In "Off-Delay" models the switch transfers the load immediately upon energization, and the delay period does not begin until the unit is de-energized. At the end of the delay period the switch returns to its original position. Re-energizing the unit during the delay period immediately resets the timing, readying it for another full delay period on de-energization. No power is required during the timing period.

In addition to these basic operating types, "Double-Head" models offer sequential delays on pull-in and drop-out in one unit. With the addition of auxiliary switches the basic models provide two-step timing, pulse actuation for interlock circuits, or added circuit capacity.

NOTE: Seismic & radiation tested E7000 models are available. Consult factory for detailed information.

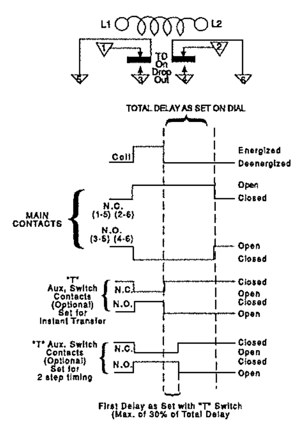
On-delay model 7012 (delay on pickup)



Applying continuous voltage to the coil (L1-L2) starts a time delay lasting for the preset time. During this period the normally closed contacts (3-5 and 4-6) remain closed. At the end of the delay period the normally closed contacts break and the normally open contacts (1-5 and 2-6) make. The contacts remain in this transferred position until the coil is deenergized, at which time the switch instantaneously returns to its original position.

De-energizing the coil, either during or after the delay period, will recycle the unit within 50 msec. It will then provide a full delay period upon re-energization, regardless of how often the coil voltage is interrupted before the unit has been permitted to "time-out" to its full delay setting.

Off-delay model 7022 (delay on dropout)



Applying voltage to the coil (for at least 50 msec) will instantaneously transfer the switch, breaking the normally closed contacts (1-5 and 2-6), and making the normally open contacts (3-5 and 4-6). Contacts remain in this transferred position as long as the coil is energized. The time delay begins immediately upon de-energization. At the end of the delay period the switch returns to its normal position.

Re-energizing the coil during the delay period will immediately return the timing mechanism to a point where it will provide a full delay period upon subsequent de-energization. The switch remains in the transferred position.

To increase the versatility of the basic timer models, auxiliary switches may be added to either on-delay or off-delay types. They switch additional circuits, provide two-step timing action, or furnish electrical interlock for sustained coil energization from a momentary impulse, depending on the type selected and its adjustment. Because of their simple attachment and adjustment features, they can be installed at the factory or in the field, by any competent mechanic. All auxiliary switches are SPDT with UL listings of 10A @ 125, 250, or 480 VAC. A maximum of one Code T or two Code L auxiliary switches may be added to each relay. The L or LL switch is available with on-delay relays only. The T switch is available with both the on-delay and off-delay relays.

Auxiliary Switch Options for On-Delay

Instant Transfer (Auxiliary Switch Code L, maximum of 2 per relay.)

1. Energizing coil begins time delay and transfers auxiliary switch.
2. Main switch transfers after total preset delay.
3. De-energizing coil resets both switches instantly.

Auxiliary switch is nonadjustable.

Two-Step Timing (Auxiliary Switch Code T, maximum of 1 per relay.)

Auxiliary switch options

To increase the versatility of the basic timer models, auxiliary switches may be added to either on-delay or off-delay types. They switch additional circuits, provide two-step timing action, or furnish electrical interlock for sustained coil energization from a momentary impulse, depending on the type selected and its adjustment. Because of their simple attachment and adjustment features, they can be installed at the factory or in the field, by any competent mechanic. All auxiliary switches are SPDT with UL listings of 10A @ 125, 250, or 480 VAC. A maximum of one Code T or two Code L auxiliary switches may be added to each relay. The L or LL switch is available with on-delay relays only. The T switch is available with both the on-delay and off-delay relays.

Auxiliary Switch Options for On-Delay

Instant Transfer (Auxiliary Switch Code L, maximum of 2 per relay.)
1. Energizing coil begins time delay and transfers auxiliary switch.
2. Main switch transfers after total preset delay.
3. De-energizing coil resets both switches instantly.

Auxiliary switch is nonadjustable.

Two-Step Timing (Auxiliary Switch Code T, maximum of 1 per relay.)
1. Energizing coil begins time delay.
2. After first delay auxiliary switch transfers.
3. Main switch transfers after total preset delay.
4. De-energizing coil resets both switches instantly. First delay is independently adjustable, up to 30% of overall delay. (Recommended maximum 100 seconds.)

Auxiliary Switch Options for Off-Delay

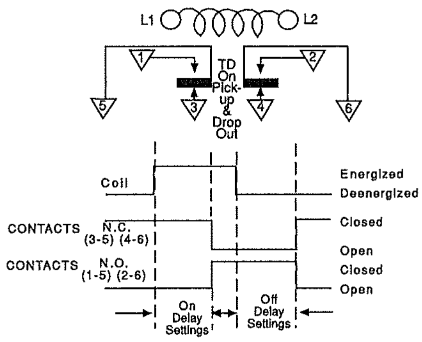
In these models the same auxiliary switch provides either two-step timing or instant transfer action, depending on the adjustment of the actuator.

Two-Step Timing (Auxiliary Switch Code T, maximum of 1 per relay.)
1. Energizing coil transfers main and auxiliary switches instantly.
2. De-energizing coil begins time delay.
3. After first delay auxiliary switch transfers.
4. Main switch transfers after total preset delay. First delay is independently adjustable, up to 30% of overall delay. (Recommended maximum 100 seconds.)

Instant Transfer (Auxiliary Switch Code L, maximum of 1 per relay.)
1. Energizing coil transfers main and auxiliary switches instantly.
2. De-energizing coil resets auxiliary switch and begins time delay.
3. Main switch transfers after total preset delay.

Auxiliary switch is factory adjusted to give instant transfer operation, but may be easily adjusted in the field to provide two-step timing.

On-delay, off-delay model 7032 (double head)

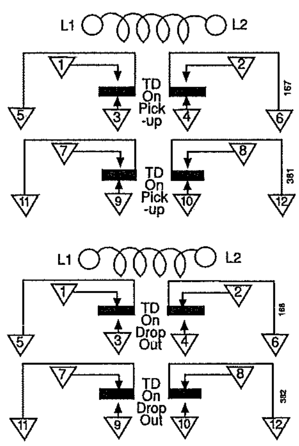


The Double Head model provides delayed switch transfer on energization of its coil, followed by delayed resetting upon coil de-energization. Each delay period is independently adjustable.

In new circuit designs or the improvement of existing controls now using two or more conventional timers, the Double Head unit offers distinct advantages.

Its compact design saves precious panel space, while the simplified wiring reduces costly interconnection.

Four pole model 7014. 7024



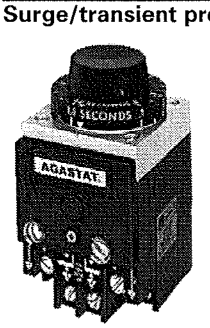
With the addition of an extra switch block at the bottom of the basic unit, this version of the Series 7000 offers four pole switch capacity with simultaneous timing or two-step timing. The two-step operation is achieved by factory adjustment to your specifications.

For two-step operation, a maximum timing ratio between upper and lower switches of 3:2 is recommended. Once adjusted at the factory, this ratio remains constant regardless of changes in dial settings. (Ex: If upper switch transfer is set on dial at 60 sec., minimum time on lower switch should be 40 sec.)

This Series 7000 unit offers many of the performance features found in basic models - voltage ranges, timing and switch capacities are virtually identical.

Four pole models add approximately 1-1/4" to the maximum height of the basic model, approximately 1/8" to the depth. They are designed for vertical operation only.

Surge/transient protection option



Transient Suppressor Option "V"

Features
- Protect electronic control circuits from voltage transients generated by the timer coil.
- Fast response to the rapidly rising back E.M.F.
- High performance clamping voltage characteristics.
- UL recognized, (except varistor and coil together).
- Timer NOT polarity sensitive.

The Surge/Transient Protection Option protects electronic control circuits from transients and surges which are generated when the timer coil is activated. Built with a minimum of moving parts, the unit provides a fast response to rapidly rising voltage transients. The accurate, precision-made device is not polarity sensitive and permits the user to initiate, delay, sequence and program equipment actions over a wide range of applications under the most severe operating conditions.

It consists of a specially modified coil case, varistor, varistor cover, terminal extensions and cup washers so that normal terminations can be used. The varistor will not affect the operating characteristics of the 7000 Timer. The varistor has bilateral and symmetrical voltage and current characteristics and therefore can be used in place of the back-to-back zener diodes. This characteristic also means that the coil will not be polarity sensitive.

Timing Specifications (All values shown are at nominal voltage and 25°C unless otherwise specified).

Operating Modes:
Model 7012/7014: On-delay (delay on pick-up).
Model 7022/7024: Off-delay (delay on drop-out).
Model 7032: On-delay, off-delay (double head).
Timing Adjustment: Timing is set by simply turning the dial to the desired time value. In the zone of approximately 25° separating the high and low end of timing ranges A,D,E, and K, instantaneous operation (no time delay) will occur. All other ranges produce an infinite time delay when the dial is set in this zone.

Models 7014 and 7032 are available with letter-calibrated dials only. The upper end of the time ranges in these models may be twice the values shown.

Linear Timing Ranges:

Code	Models 7012, 7022, 7024	Models 7014, 7032
A	.1 to 1 Sec.	.2 to 2 Sec.
B	.5 to 5 Sec.	.7 to 7 Sec.
C	1.5 to 15 Sec	2 to 20 Sec.
D	5 to 50 Sec.	10 to 100 Sec.
E	20 to 200 Sec.	30 to 300 Sec.
F	1 to 10 Min.	1.5 to 15 Min.
H	3 to 30 Min.	3 to 30 Min.
I	6 to 60 Min.	Not Avail.
J	3 to 120 Cyc.	Not Avail.
K	1 to 300 Sec.	Not Avail.

Repeat Accuracy:

For delays of 200 seconds or less:	7012*, 7022, 7024:	±5%
	7014*:	±10%
	7032:	±15%
For delays greater than 200 seconds:	7012*, 7022, 7014*, 7024:	±10%
	7032:	±15%

* The first time delay afforded by Model 7012 with H (3 to 30 min.) and I (6 to 60 min.) time ranges or Model 7014 with H time range will be approx. 15% longer than subsequent delays due to coil temperature rise.

Reset Time: 50 msec. (except model 7032)
Relay Release Time: 50 msec. for on-delay models (7012/7014)
Relay Operate Time: 50 msec. for off-delay models (7022/7024)

Operating Voltage Coil Data (for DPDT)

Coil Part #	Code Letter	Rated Voltage	Operating* Voltage Range @ 60Hz	Rated Voltage	Operating Voltage Range @50Hz
7000	A	120	102-132	110	93.5-121
	B	240	204-264	220	187-242
	C	480	408-528		
	D	550	468-605		
	E	24	20.5-26.5		
AC	F			127	108-140
	G			240	204-264
	H	12	10.2-13.2		
	I	6	5.1-6.6		
	J	208	178-229		
	K		Dual Voltage Coil (Combines A&B)		
	L		Special AC Coils (L1, L2, etc.)		
7010	M	28	22.4-30.8		
	N	48	38.4-52.8		
	O	24	19.2-26.4		
	P	125	100-137.5		
	Q	12	9.6-13.2		
	R	60	48-66		
DC	S	250	200-275		
	T	550	440-605		
	U	16	12.8-17.6		
	V	32	25.8-35.2		
	W	96	76.8-105.6		
	Y	6	4.8-6.6		
	Z	220	176-242		
	X		Special DC Coils (X1, X2, etc.)		

*Four pole Models: Operational voltage range 90% to 110% for AC units; 85% to 110% for DC units.

See next column for more coil data.

Minimum operating voltages are based on vertically mounted 7012 units. 7012 horizontally mounted or 7022 vertically or horizontally mounted units will operate satisfactorily at minimum voltages approximately 5% lower than those listed.
AC units drop out at approximately 50% of rated voltage. DC units drop out at approximately 10% of rated voltage.
All units may be operated on intermittent duty cycles at voltages 10% above the listed maximums (intermittent duty - maximum 50% duty cycle and 30 minutes "on" time.)

Surge/Transient Protection Option Characteristics (DC Timers Only)

Coil Voltage Nominal (DC)	Max Excess Energy Capacity (Joule)	Max De-energization Transient Voltage
12 V	0.4 J	48 V
24 V	1.8 J	93 V
28 V	1.8 J	93 V
32 V	2.5 J	135 V
48 V	3.57 J	145 V
60 V	6 J	250 V
96 V	10 J	340 V
110 V	10 J	340 V
125 V	10 J	340 V
220 V	17 J	366 V
250 V	17 J	366 V

Surge Life
Applied 100,000 times continuously with the interval of 10 seconds at room temperature. Below 68 VAC: 12A; Above 68 VAC: 35A
Temperature Range
Operating: -22°F to +167°F (-30°C to + 75°C)
Storage: -40°F to +167°F (-40°C to +75°C)

Output/Life Contact Ratings: Contact Capacity in Amps (Resistive Load)

Contact Voltage	Min. 100,000 Operations	Min. 1,000,000 Operations
30 VDC	15.0	7.0
110 VDC	1.0	0.5
120 V 60Hz	20.0	15.0
240 V 60Hz	20.0	15.0
480 V 60Hz	12.0	10.0

10 Amps Resistive, 240 VAC
1/4 Horsepower, 120 VAC/240VAC (per pole)
15 Amps 30 VDC (per pole)
5 Amps, General Purpose, 600VAC (per pole)
Dielectric: Withstands 1500 volts RMS 60Hz between terminals and ground. 1,000 volts RMS 60 Hz between non-connected terminals. For dielectric specification on hermetically sealed models consult factory.
Insulation Resistance: 500 Megohms with 500VDC applied.
Temperature Range: Operating: -20°F to +165°F (-29°C to 74°C)
Storage: -67°F to +165°F (-55°C to 74°C)
Temperature Variation: Using a fixed time delay which was set and measured when the ambient temperature was 77°F (25°C), the maximum observed shift in the average of three consecutive time delays was -20% at -20°F (-29°C) and +20% at 165°F (74°C).
Mounting/Terminals: Normal mounting of the basic unit is in a vertical position, from the back of the panel. A front mounting bracket is also supplied with each basic unit, for installation from the front of the panel. **All units are calibrated for vertical operation.** Basic models (7012, 7022) may also be horizontally mounted, and will be adjusted accordingly **when Accessory Y1 is specified in your order.**

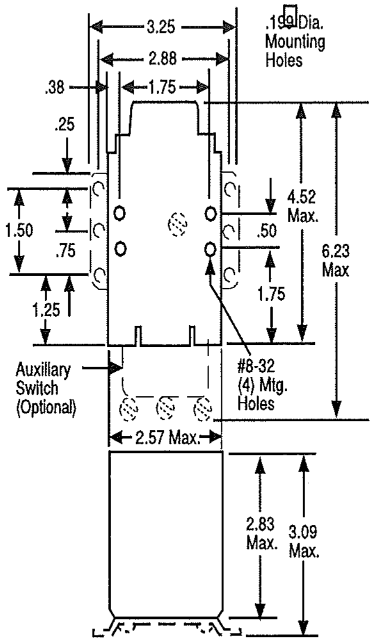
Standard screw terminals (8-32 truss head screws supplied) are located on the front of the unit, with permanent schematic markings. Barrier isolation is designed to accommodate spade or ring tongue terminals, with spacing to meet all industrial control specifications.

The basic Series 7000 may also be panel mounted with the addition of a panelmount kit that includes all necessary hardware and faceplate. This offers the convenience of "out-front" adjustment, with large calibrated dial skirt knob. The faceplate and knob blend with advanced equipment and console designs, while the body of the unit and its wiring are protected behind the panel.

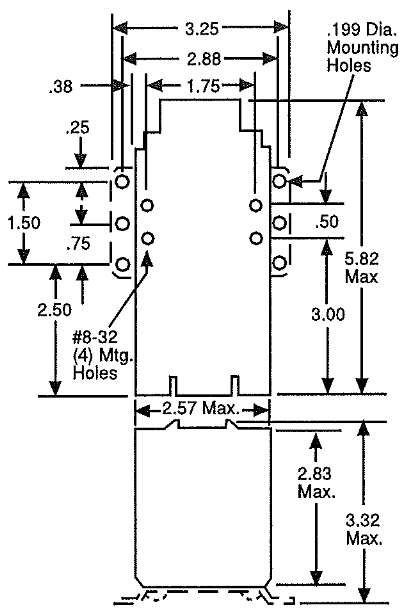
Other mounting options include plug-in styles and special configurations to meet unusual installation requirements. Contact factory for details.
Power Consumption: Approximately 8 watts power at rated voltage .
Approximate Weights:
Models 7012, 7022 . . . . 2 lbs. 4 ozs.
7014, 7024 . . . . 2 lbs. 10 ozs.
7032 . . . . 3 lbs. 5 ozs.
Weight may vary slightly with coil voltage.

Outline Dimensions (Dimensions in inches).

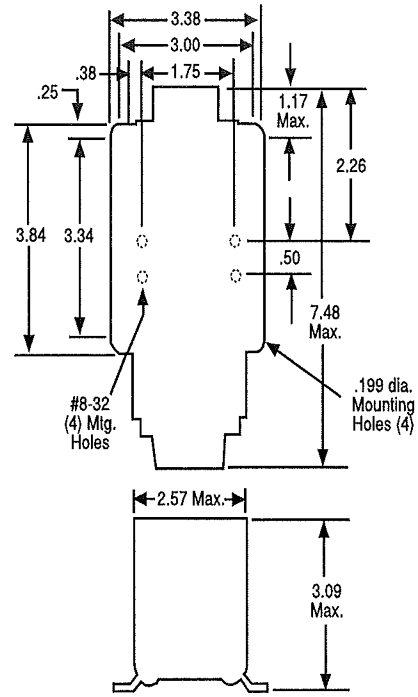
Models 7012, 7022



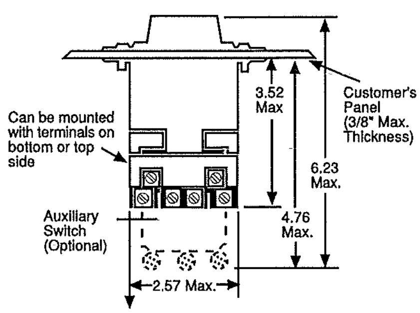
Models 7014, 7024

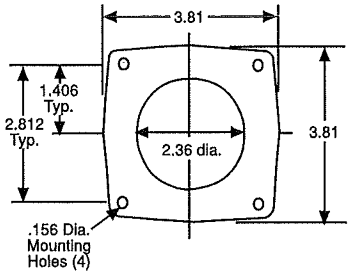


Model 7032

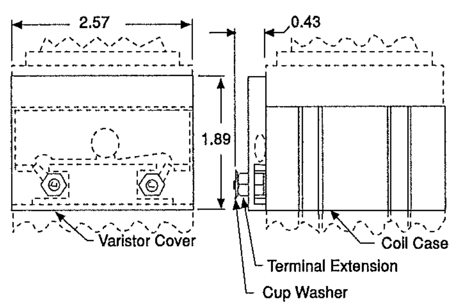


Panel mount Option "X"





Surge/Transient Protection Option



Ordering Information

Typical Part No. ➤ 70 | 1 | 2 | A | D | GZ

1. Basic Series:
70 = 7000 series electropneumatic timing relay

2. Operation:
1 = On-delay
2 = Off-delay
3 = On-delay, off-delay (double head)

3. Contact Arrangement:
2 = 2PDT (2 form C)
**4 = 4PDT (4 form C)

4. Coil Voltage:

AC Coils
A = 120VAC, 60 Hz.; 110VAC, 50Hz.
B = 240VAC, 60 Hz.; 220VAC, 50Hz.
C = 480VAC, 60 Hz.
D = 550VAC, 60 Hz.
E = 24VAC, 60 Hz.
F = 127VAC, 50 Hz.
G = 240VAC, 50Hz.
H = 12VAC, 60 Hz.
K = Dual voltage (combines A & B)
L = Special AC coils (L1, L2, etc.)

DC Coils
M = 28VDC
N = 48VDC
O = 24VDC
P = 125VDC
Q = 12VDC
R = 60VDC
S = 250VDC
T = 550VDC
U = 16VDC
V = 32VDC
W = 96VDC
Y = 6VDC
Z = 220VDC
X = Special DC coils (X1, X2, etc.)

5. Timing Range:

Models 7012, 7022 & 7024
A = .1 to 1 sec.
B = .5 to 5 sec.
C = 1.5 to 15 sec.
D = 5 to 50 sec.
E = 20 to 200 sec.
F = 1 to 10 min.
H = 3 to 30 min.
I = 6 to 60 min.
J = 3 to 120 cyc.
K = 1 to 300 sec.

†Models 7014 & 7032
For model 7032 specify separate time range code for each head. Example: AB. Any two ranges may be selected.
A = .2 to 2 sec.
B = .7 to 7 sec.
C = 2 to 20 sec.
D = 10 to 100 sec.
E = 30 to 300 sec.
F = 1.5 to 15 min.
H = 3 to 30 min.

6. Options:
A1 = Single quick-connect terminals (note 4).
A2 = Double quick-connect terminals (note 4).
B = Plug-in connectors (note 4).
GZ = Enclosure with bottom knockouts (note 1).
H2 = Hermetically sealed enclosure, 8 pin solder (notes 1 & 4).
H3 = Hermetically sealed enclosure, 8 pin octal (notes 1 & 4).
H4 = Hermetically sealed enclosure, 8 screw terminal block (notes 1 & 4).
*H6 = Hermetically sealed enclosure, 11 pin solder (notes 1 & 4).
*H7 = Hermetically sealed enclosure, 11 pin octal (notes 1 & 4).
*H8 = Hermetically sealed enclosure, 11 screw terminal block (notes 1 & 4).
I1 = Tamper-proof Cap, opaque black (Cannot be combined with Option X).
I2 = Tamper-proof Cap, transparent (Cannot be combined with Option X).
K = Explosion-proof Enclosure (note 1).
L = Auxiliary Switch, instant transfer. 7012 only (notes 2 & 6).
LL = Two Aux. Switches, instant transfer. On Model 7014 Factory Installed Only. (notes 2 & 6)
M = Dust-tight Gasketing (notes 4 & 5).
P = Octal Plug Adapter. Can be combined only with options I1,I2. M, S, X, or Y1. (note 4).
S = Dial Stops.
T = Auxiliary Switch, two-step timing (notes 2 & 6).
V = Transient/Surge Protection (for DC coil voltage only).
W = Watertight Enclosure (note 1).
X = Panelmount includes hardware and adjustment for horizontal operation (note 4)
Y1 = Horizontal calibration, for horizontal operation without panelmounting (note 4).
Y2 = Horizontal calibration, with Compensating Spring for vertical operation (note 4).

Notes:
1. Cannot be combined with B, P or X Options
2. Cannot be combined with B, P or Y2 Options
3. Cannot be combined with GZ, H, I1, I2, K, W or Y1 Options
4. Not Avail. on 4-Pole Models
5. Not Available with L, T or LL options.
6. Not Available on hermetically sealed units.

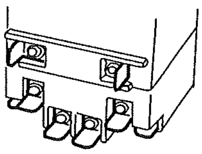
* Sized to accommodate one L or T Auxiliary Switch
** Not available on On-Delay, Off-Delay (Double Head) model.
† Available with letter calibrated dials only. Upper end of time range may be twice the value shown
†† 120 cycles = 2 sec.

Our authorized distributors are more likely to maintain the following items in stock for immediate delivery..

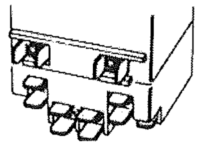
7012AA	7012BC	7012PKX	7022AI
7012AB	7012NC	7012PJX	7022AJ
7012AC	7012PA	7022AA	7022AKT
7012AD	7012PB	7022AB	7022BC
7012AE	7012PC	7022AC	7022BK
7012AF	7012PD	7022AD	7022PA
7012AH	7012PF	7022AE	7022PB
7012AK	7012PJ	7022AF	7022PC
7012ACL	7012PK	7022AH	7022PK

Ordering options – can only be orderd as factory installed options (Dimensions, where shown, are in inches.)

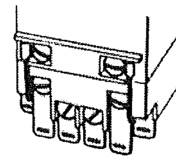
A1 – Single Quick-Connect Terminals



A2 – Double Quick-Connect Terminals

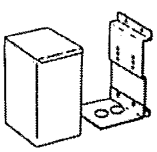


B – Plug-In Connectors



Use with Accessory "C" or "D" below.

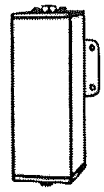
GZ – Total Enclosure



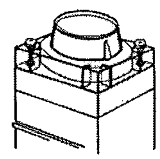
With knockouts for bottom connection.

3.16" W x 3.84" D x 7.63"H

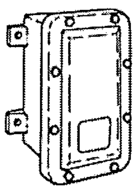
H – Hermetically Sealed Enclosure



I – Tamper-Proof Cover



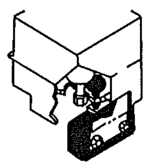
K – Explosion proof Enclosure



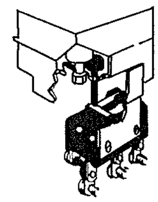
(Meets requirements for Class I, Groups C&D locations).

7.50"W x 6.00" D x 10.38" H

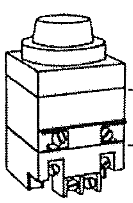
L – Auxiliary Switch



LL – Auxiliary Switch



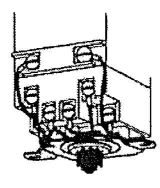
M – Dustight



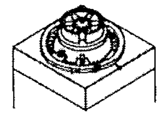
—Gasket

Gasket

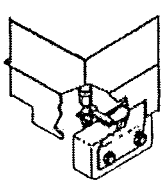
P – Octal Plug Adapter



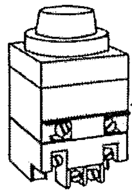
S – Dial Stops



T – Auxiliary Switch

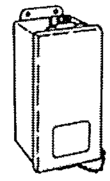


V – Transient/Surge Protection



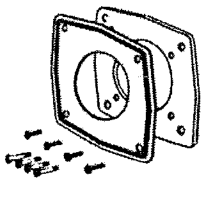
←Transient Protection

W – Watertight Enclosure (NEMA-4)



4.75" W x 4.44" D x 9.75" H

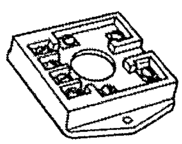
X – Panelmount Kit



Mounting hardware included.

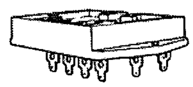
Accessories (Not available for 7032 models)

Plug-In Receptacle (Accessory C)



Screw Terminals **Catalog No. 700137.** For use with "B" Option

Plug-In Receptacle (Accessory D)



Quick Connect Terminals **Catalog No. 700141.** For use with "B" Option.

Ordering options can only be ordered as factory installed options.

42.302.07 As-Found As-Left Data
for Pick-Up (Operate) Setting and Time Delay

		Pickup			Time Delay		
Relay	Date	AF	AL	% Drift	AF	AL	% Drift
XY-27A	2/5/1999		87.53			2.00	
	10/31/2000	87.49	86.69	-0.05%	2.01	2.01	0.50%
	5/3/2002	86.90	86.90	0.24%	2.00	2.00	-0.50%
	2/21/2004	87.00	87.00	0.12%	2.00	2.00	0.00%
	4/28/2005	87.30	86.60	0.34%	2.00	2.01	0.00%
	10/27/2006	86.50	86.50	-0.12%	2.00	2.00	-0.40%
	6/20/2008	86.70	86.70	0.23%	2.00	2.00	-0.10%
	1/22/2010	87.00	87.00	0.35%	2.00	2.00	-0.05%
YZ-27A	2/5/1999		87.73			2.00	
	10/31/2000	87.69	86.58	-0.05%	2.00	2.00	0.00%
	5/3/2002	86.80	86.80	0.25%	2.02	2.02	1.00%
	2/21/2004	86.80	86.80	0.00%	2.00	2.00	-0.99%
	4/28/2005	87.10	87.10	0.35%	2.00	2.00	0.00%
	10/27/2006	87.00	87.00	-0.11%	2.00	2.00	0.15%
	6/20/2008	87.20	86.60	0.23%	2.00	2.00	-0.15%
	1/22/2010	86.80	86.80	0.23%	2.00	2.00	0.05%
XN-27C	2/5/1999		87.54			2.00	
	10/31/2000	87.69	87.69	0.17%	2.00	2.00	0.00%
	5/3/2002	87.70	87.70	0.01%	2.01	2.01	0.50%
	2/21/2004	87.70	87.70	0.00%	2.00	2.00	-0.50%
	4/28/2005	87.80	87.80	0.11%	2.00	2.00	0.00%
	10/27/2006	87.90	87.90	0.11%	2.00	2.00	0.00%
	6/20/2008	88.00	87.50	0.11%	2.00	2.00	0.00%
	1/22/2010	87.50	87.50	0.00%	2.00	2.00	-0.15%
YN-27C	2/5/1999		87.83			2.00	
	10/31/2000	87.78	87.78	-0.06%	2.01	2.01	0.50%
	5/3/2002	88.00	88.00	0.25%	2.00	2.00	-0.50%
	2/21/2004	88.00	88.00	0.00%	2.00	2.00	0.00%
	4/28/2005	88.30	87.40	0.34%	2.00	2.00	0.00%
	10/27/2006	87.30	87.30	-0.11%	2.00	2.00	0.05%
	6/20/2008	87.30	87.30	0.00%	2.00	2.00	-0.05%
	1/22/2010	87.50	87.50	0.23%	2.00	2.00	-0.10%

		Pickup			Time Delay		
Relay	Date	AF	AL	% Drift	AF	AL	% Drift
XY-27B	2/5/1999		114.42			2.03	
	10/31/2000	114.49	113.00	0.06%	2.03	2.03	0.00%
	5/3/2002	113.10	113.10	0.09%	2.03	2.03	0.00%
	2/21/2004	113.20	113.20	0.09%	2.03	2.03	0.00%
	4/28/2005	113.30	113.30	0.09%	2.04	2.04	0.49%
	10/27/2006	113.20	113.20	-0.09%	2.03	2.03	-0.44%
	6/20/2008	113.40	113.40	0.18%	2.03	2.03	0.00%
	1/22/2010	113.30	113.30	-0.09%	2.03	2.03	-0.05%
YZ-27B	2/5/1999		114.42			2.01	
	10/31/2000	114.29	112.89	-0.11%	2.01	2.01	0.00%
	5/3/2002	113.20	113.20	0.27%	2.01	2.01	0.00%
	2/21/2004	113.20	113.20	0.00%	2.01	2.01	0.00%
	4/28/2005	113.40	113.40	0.18%	2.02	2.02	0.50%
	10/27/2006	113.30	113.30	-0.09%	2.01	2.01	-0.59%
	6/20/2008	113.50	112.70	0.18%	2.01	2.01	0.00%
	1/22/2010	112.70	112.70	0.00%	2.01		0.10%
XN-27D	2/5/1999		114.23			2.03	
	10/31/2000	114.19	114.19	-0.04%	2.03	2.03	0.00%
	5/3/2002	114.50	114.50	0.27%	2.01	2.03	-0.99%
	2/21/2004	114.50	114.50	0.00%	2.03	2.03	0.00%
	4/28/2005	114.60	114.00	0.09%	2.04	2.02	0.49%
	10/27/2006	113.90	113.90	-0.09%	2.03	2.03	0.69%
	6/20/2008	114.10	114.10	0.18%	2.03	2.03	-0.15%
	1/22/2010	114.20	114.20	0.09%	2.03	2.03	-0.05%
ZN-27D	2/5/1999		114.52			2.02	
	10/31/2000	114.00	113.80	-0.45%	2.02	1.98	0.00%
	5/3/2002	114.50	114.50	0.62%	1.98	1.98	0.00%
	2/21/2004	114.30	114.30	-0.17%	1.98	1.98	0.00%
	4/28/2005	114.30	114.30	0.00%	1.98	1.98	0.00%
	10/27/2006	114.40	114.40	0.09%	1.98	1.98	-0.10%
	6/20/2008	114.40	114.40	0.00%	1.98	1.98	-0.05%
	1/22/2010	114.50	114.50	0.09%	1.98	0.20	0.15%
1RU62	2/5/1999					41.60	
	10/31/2000				41.73	41.73	0.31%
	5/3/2002				43.21	42.89	3.55%
	2/21/2004				41.01	41.01	-4.38%
	4/28/2005				43.17	42.88	5.27%
	10/27/2006				38.60	41.40	-9.98%
	6/20/2008				42.30	42.30	2.17%
	1/22/2010				40.40	41.60	-4.49%

42.302.08 As-Found As-Left Data
for Pick-Up (Operate) Setting
and Time Delay

		Pickup			Time Delay		
DSN	Date	AF	AL	%Drift	AF	AL	%Drift
XY-27A	2/11/1999	87.93	87.93		2.02	2.02	
	11/7/2000	88.02	86.62	0.10%	2.02	2.02	0.00%
	5/10/2002	86.60	86.60	-0.02%	2.02	2.02	0.00%
	12/5/2003	86.70	86.70	0.12%	2.02	2.02	0.00%
	5/5/2005	86.70	86.70	0.00%	2.02	2.02	0.00%
	11/29/2006	86.70	86.70	0.00%	2.02	2.02	0.00%
	5/2/2008	87.00	87.00	0.35%	2.02	2.02	0.00%
	1/29/2010	87.00	88.00	0.00%	2.02	2.02	0.00%
YZ-27A	2/11/1999	87.94	87.94		2.01	2.01	
	11/7/2000	87.94	86.62	0.00%	2.01	2.01	0.00%
	5/10/2002	86.60	86.60	-0.02%	2.01	2.01	0.00%
	12/5/2003	86.70	86.70	0.12%	2.01	2.01	0.00%
	5/5/2005	86.80	86.80	0.12%	2.01	2.01	0.00%
	11/29/2006	86.80	86.80	0.00%	2.00	2.00	-0.50%
	5/2/2008	86.90	86.90	0.12%	2.01	2.01	0.35%
	1/29/2010	87.00	87.00	0.12%	2.01	2.01	0.15%
XN-27C	2/11/1999	87.88	87.88		2.02	2.02	
	11/7/2000	87.93	87.93	0.06%	2.02	2.02	0.00%
	5/10/2002	87.90	87.90	-0.03%	2.01	2.01	-0.50%
	12/5/2003	88.02	87.80	0.14%	2.01	2.01	0.00%
	5/5/2005	87.10	87.10	**-0.80%**	2.02	2.02	0.50%
	11/29/2006	87.10	87.10	0.00%	2.01	2.01	-0.50%
	5/2/2008	87.20	87.20	0.11%	2.01	2.01	0.15%
	1/29/2010	87.20	87.20	0.00%	2.01	2.01	-0.15%
YN-27C	2/11/1999	87.87	87.87		2.04	2.04	
	11/7/2000	87.80	87.80	-0.08%	2.04	2.04	0.00%
	5/10/2002	88.00	88.00	0.23%	2.04	2.04	0.00%
	12/5/2003	88.60	87.10	**0.68%**	2.04	2.04	0.00%
	5/5/2005	87.10	87.10	0.00%	2.04	2.04	0.00%
	11/29/2006	87.10	87.10	0.00%	2.04	2.04	0.00%
	5/2/2008	86.90	87.30	-0.23%	2.04	2.04	-0.05%
	1/29/2010	87.30	87.30	0.00%	2.04	2.04	0.05%

		Pickup			Time Delay		
DSN	Date	AF	AL	%Drift	AF	AL	%Drift
XY-27B	2/11/1999	114.28	114.28		2.00	2.00	
	11/7/2000	114.19	112.69	-0.08%	2.00	2.00	0.00%
	5/10/2002	113.00	113.00	0.28%	2.01	2.01	0.50%
	12/5/2003	114.40	113.00	**1.24%**	2.01	2.01	0.00%
	5/5/2005	111.30	112.70	**-1.50%**	2.00	2.00	-0.50%
	11/29/2006	112.70	112.70	0.00%	2.00	2.00	0.00%
	5/2/2008	112.80	112.80	0.09%	2.00	2.00	0.20%
	1/29/2010	112.80	112.80	0.00%	2.00	2.00	-0.10%
YZ-27B	2/11/1999	114.68	114.68		2.00	2.00	
	11/7/2000	113.89	113.00	-0.69%	2.00	2.00	0.00%
	5/10/2002	113.30	113.30	0.27%	2.00	2.00	0.00%
	12/5/2003	113.50	113.00	0.18%	2.00	2.00	0.00%
	5/5/2005	112.20	112.70	**-0.71%**	2.00	2.00	0.00%
	11/29/2006	112.70	112.70	0.00%	1.99	1.99	-0.50%
	5/2/2008	112.80	112.80	0.09%	2.00	2.00	0.25%
	1/29/2010	113.00	113.00	0.18%	1.99	1.99	-0.05%
XN-27D	2/11/1999	114.63	114.63		2.01	2.01	
	11/7/2000	114.00	114.00	**-0.55%**	2.01	2.01	0.00%
	5/10/2002	114.20	114.20	0.18%	2.01	2.01	0.00%
	12/5/2003	114.50	113.90	0.26%	2.01	2.01	0.00%
	5/5/2005	114.00	114.00	0.09%	2.01	2.01	0.00%
	11/29/2006	113.90	113.90	-0.09%	2.01	2.01	0.00%
	5/2/2008	114.20	114.20	0.26%	2.01	2.01	0.15%
	1/29/2010	114.20	114.20	0.00%	2.01	2.01	-0.10%
ZN-27D	2/11/1999	113.94	113.94		2.00	2.00	
	11/7/2000	113.72	113.72	-0.19%	2.00	2.00	0.00%
	5/10/2002	114.00	114.00	0.25%	2.00	2.00	0.00%
	12/5/2003	114.10	114.10	0.09%	2.00	2.00	0.00%
	5/5/2005	114.30	114.30	0.18%	2.00	2.00	0.00%
	11/29/2006	114.10	114.10	-0.17%	2.00	2.00	0.00%
	5/2/2008	114.30	114.30	0.18%	2.00	2.00	0.00%
	1/29/2010	114.40	114.40	0.09%	2.00	2.00	-0.05%
1RV62	2/11/1999				43.46	41.83	
	11/7/2000				41.10	41.10	-1.75%
	5/10/2002				42.60	42.60	3.65%
	12/5/2003				42.88	42.88	0.66%
	5/5/2005				41.20	41.20	-3.92%
	11/29/2006				39.30	41.40	-4.61%
	5/2/2008				41.70	41.70	0.72%
	1/29/2010				41.60	41.60	-0.24%

		Pickup			Time Delay		
Relay	Date	AF	AL	%Drift	AF	AL	%Drift
XY-27A	11/21/2000	88.700	88.200		1.990	1.990	
	5/28/2002	88.100	88.100	-0.11%	1.970	1.970	**-1.01%**
	12/9/2003	88.400	88.400	0.34%	1.970	1.970	0.00%
	6/10/2005	88.400	88.400	0.00%	1.970	1.970	0.00%
	10/13/2006	88.400	88.400	0.00%	1.969	1.969	-0.05%
	6/6/2008	88.400	88.400	0.00%	1.967	1.967	-0.10%
	12/4/2009	88.400	88.400	0.00%	1.960	1.960	-0.36%
	3/1/2010	88.400	88.400	0.00%	1.960	1.960	0.00%
YZ-27A	11/21/2000	88.400	87.900		2.000	2.000	
	5/28/2002	87.800	87.800	-0.11%	2.000	2.000	0.00%
	12/9/2003	87.900	87.900	0.11%	2.000	2.000	0.00%
	6/10/2005	87.800	87.800	-0.11%	2.000	2.000	0.00%
	10/13/2006	87.900	87.900	0.11%	2.004	2.004	0.20%
	6/6/2008	87.900	87.900	0.00%	2.002	2.002	-0.10%
	12/4/2009	88.000	88.000	0.11%	2.000	2.000	-0.10%
	3/1/2010	88.000	88.000	0.00%	2.000	2.000	0.00%
XN-27C	11/21/2000	89.100	89.100		2.010	2.010	
	5/28/2002	89.300	89.300	0.22%	2.000	2.000	-0.50%
	12/9/2003	90.600	88.600	**1.46%**	2.010	2.010	0.50%
	6/10/2005	87.900	87.900	**-0.79%**	2.000	2.000	-0.50%
	10/13/2006	88.400	88.400	**0.57%**	2.006	2.006	0.30%
	6/6/2008	88.400	88.400	0.00%	2.003	2.003	-0.15%
	12/4/2009	88.400	88.400	0.00%	2.000	2.000	-0.15%
	3/1/2010	88.400	88.400	0.00%	2.000	2.000	0.00%
YN-27C	11/21/2000	88.600	88.600		2.010	2.010	
	5/28/2002	89.000	89.000	0.45%	1.990	1.990	**-1.00%**
	12/9/2003	89.700	88.700	**0.79%**	1.990	1.990	0.00%
	6/10/2005	88.200	88.700	**-0.56%**	2.000	2.000	0.50%
	10/13/2006	88.700	88.700	0.00%	1.995	1.995	-0.25%
	6/6/2008	88.800	88.800	0.11%	1.992	1.992	-0.15%
	12/4/2009	88.900	88.900	0.11%	1.990	1.990	-0.10%
	3/1/2010	88.900	88.900	0.00%	1.990	1.990	0.00%

		Pickup			Time Delay		
Relay	Date	AF	AL	%Drift	AF	AL	%Drift
XY-27B	11/21/2000	106.800	105.500		2.000	2.000	
	5/28/2002	105.600	105.600	0.09%	1.990	1.990	-0.50%
	12/9/2003	108.100	105.900	**2.37%**	1.990	1.990	0.00%
	6/10/2005	105.000	105.400	**-0.85%**	2.000	2.000	0.50%
	10/13/2006	105.400	105.400	0.00%	1.998	1.998	-0.10%
	6/6/2008	105.500	105.500	0.09%	2.003	2.003	0.25%
	12/4/2009	105.500	105.500	0.00%	2.000	2.000	-0.15%
	3/1/2010	105.500	105.500	0.00%	1.995	1.995	-0.25%
YZ-27B	11/21/2000	106.900	105.900		2.000	2.000	
	5/28/2002	106.100	106.100	0.19%	2.000	2.000	0.00%
	12/9/2003	106.100	106.100	0.00%	2.000	2.000	0.00%
	6/10/2005	106.100	106.100	0.00%	2.000	2.000	0.00%
	10/13/2006	106.000	106.000	-0.09%	2.005	2.005	0.25%
	6/6/2008	106.100	106.100	0.09%	2.004	2.004	-0.05%
	12/4/2009	106.200	106.200	0.09%	2.000	2.000	-0.20%
	3/1/2010	105.900	105.900	-0.28%	2.003	2.003	0.15%
YN-27D	11/21/2000	106.900	106.900		2.000	2.000	
	5/28/2002	107.100	107.100	0.19%	1.990	1.990	-0.50%
	12/9/2003	107.200	107.200	0.09%	1.990	1.990	0.00%
	6/10/2005	107.100	107.100	-0.09%	2.010	2.010	1.01%
	10/13/2006	107.000	107.000	-0.09%	1.998	1.998	-0.60%
	6/6/2008	107.200	107.200	0.19%	1.998	1.998	0.00%
	12/4/2009	107.300	107.300	0.09%	2.000	2.000	0.10%
	3/1/2010	107.100	107.100	-0.19%	1.995	1.995	
ZN-27D	11/21/2000	106.800	106.800		2.010	2.010	
	5/28/2002	107.100	107.100	0.28%	2.010	2.010	0.00%
	12/9/2003	107.320	107.000	0.21%	2.010	2.010	0.00%
	6/10/2005	106.800	106.800	-0.19%	2.010	2.010	0.00%
	10/13/2006	106.700	106.700	-0.09%	2.011	2.011	0.05%
	6/6/2008	106.900	106.900	0.19%	2.009	2.009	-0.10%
	12/4/2009	107.000	107.000	0.09%	2.010	2.010	0.05%
	3/1/2010	107.200	107.200	0.19%	2.008	2.008	-0.10%
YN-27D	11/21/2000				19.800	19.800	
	5/28/2002				20.090	19.320	1.46%
	12/9/2003				19.300	19.300	-0.10%
	6/10/2005				19.200	19.200	-0.52%
	10/13/2006				19.900	19.900	3.65%
	6/6/2008				20.100	19.500	1.01%
	12/4/2009				27.200	19.700	39.49%
	3/1/2010				16.520	19.260	-16.14%

42.302.10 As-Found As-Left Data
for Pick-Up (Operate) Setting
and Time Delay

		Pickup			Time Delay		
Relay	Date	AF	AL	%Drift	AF	AL	%Drift
XY-27A	2/26/1999	89.070	89.070		2.000	2.000	
	11/27/2000	89.190	88.480	0.13%	2.000	2.000	0.00%
	5/17/2002	88.300	88.300	-0.20%	1.990	1.990	-0.50%
	1/14/2004	88.500	88.500	0.23%	2.000	2.000	0.50%
	5/20/2005	88.300	88.300	-0.23%	2.000	2.000	0.00%
	11/17/2006	88.300	88.300	0.00%	1.990	1.990	-0.50%
	5/9/2008	88.300	88.300	0.00%	1.996	1.996	0.30%
	12/11/2009	88.500	88.500	0.23%	1.994	1.994	-0.10%
YZ-27A	2/26/1999	89.360	88.760		1.980	1.980	
	11/27/2000	88.790	88.400	0.03%	1.980	1.980	0.00%
	5/17/2002	88.200	88.200	-0.23%	1.980	1.980	0.00%
	1/14/2004	88.500	88.500	0.34%	1.980	1.980	0.00%
	5/20/2005	88.300	88.300	-0.23%	1.980	1.980	0.00%
	11/17/2006	88.300	88.300	0.00%	1.980	1.980	0.00%
	5/9/2008	88.300	88.300	0.00%	1.977	1.977	-0.15%
	12/11/2009	88.500	88.500	0.23%	1.975	1.975	-0.10%
XN-27C	2/26/1999	88.670	88.670		2.000	2.000	
	11/27/2000	88.780	88.780	0.12%	1.990	1.990	-0.50%
	5/17/2002	88.700	88.700	-0.09%	1.990	1.990	0.00%
	1/14/2004	88.900	88.900	0.23%	1.990	1.990	0.00%
	5/20/2005	88.700	88.700	-0.22%	1.990	1.990	0.00%
	11/17/2006	88.700	88.700	0.00%	1.990	1.990	0.00%
	5/9/2008	88.700	88.700	0.00%	1.995	1.995	0.25%
	12/11/2009	88.800	88.800	0.11%	1.994	1.994	-0.05%
YN-27C	2/26/1999	88.970	88.970		2.000	2.000	
	11/27/2000	89.080	89.080	0.12%	2.010	2.010	0.50%
	5/17/2002	89.200	89.200	0.13%	1.990	1.990	-1.00%
	1/14/2004	89.300	89.300	0.11%	2.000	2.000	0.50%
	5/20/2005	89.200	89.200	-0.11%	2.000	2.000	0.00%
	11/17/2006	89.300	89.300	0.11%	1.990	1.990	-0.50%
	5/9/2008	89.300	89.300	0.00%	1.993	1.993	0.15%
	12/11/2009	89.300	89.300	0.00%	1.992	1.992	-0.05%

		Pickup			Time Delay		
Relay	Date	AF	AL	%Drift	AF	AL	%Drift
XY-27B	2/26/1999	106.960	106.960		2.000	2.000	
	11/27/2000	106.900	106.000	-0.06%	1.990	1.990	-0.50%
	5/17/2002	106.100	106.100	0.09%	1.990	1.990	0.00%
	1/14/2004	106.300	106.300	0.19%	2.000	2.000	0.50%
	5/20/2005	106.400	105.600	0.09%	2.000	2.000	0.00%
	11/17/2006	105.800	105.800	0.19%	2.000	2.000	0.00%
	5/9/2008	105.900	105.900	0.09%	1.995	1.995	-0.25%
	12/11/2009	105.800	105.800	-0.09%	1.995	1.995	0.00%
YZ-27B	2/26/1999	107.170	107.170		2.000	2.000	
	11/27/2000	107.300	106.100	0.12%	2.000	2.000	0.00%
	5/17/2002	106.100	106.100	0.00%	2.000	2.000	0.00%
	1/14/2004	106.300	106.300	0.19%	2.000	2.000	0.00%
	5/20/2005	106.200	106.200	-0.09%	2.000	2.000	0.00%
	11/17/2006	106.200	106.200	0.00%	2.000	2.000	0.00%
	5/9/2008	106.300	106.300	0.09%	2.000	2.000	0.00%
	12/11/2009	106.300	106.300	0.00%	1.999	1.999	-0.05%
YN-27D	2/26/1999	106.870	106.870		1.990	1.990	
	11/27/2000	106.900	106.900	0.03%	1.990	1.990	0.00%
	5/17/2002	107.200	107.200	0.28%	1.990	1.990	0.00%
	1/14/2004	107.200	107.200	0.00%	1.990	1.990	0.00%
	5/20/2005	107.200	107.200	0.00%	1.990	1.990	0.00%
	11/17/2006	107.300	107.300	0.09%	1.990	1.990	0.00%
	5/9/2008	107.500	107.100	0.19%	1.991	1.991	0.05%
	12/11/2009	106.900	106.900	-0.19%	1.990	1.990	-0.05%
ZN-27D	2/26/1999	107.070	107.070		2.000	2.000	
	11/27/2000	107.200	107.200	0.12%	2.000	2.000	0.00%
	5/17/2002	107.300	107.300	0.09%	2.000	2.000	0.00%
	1/14/2004	107.300	107.300	0.00%	2.000	2.000	0.00%
	5/20/2005	107.400	107.300	0.09%	2.000	2.020	0.00%
	11/17/2006	107.400	107.000	0.09%	2.030	2.030	0.50%
	5/9/2008	107.100	107.100	0.09%	2.025	2.025	-0.25%
	12/11/2009	107.200	107.200	0.09%	2.024	2.024	-0.05%
1RX-62	2/26/1999				19.680	19.680	
	11/27/2000				19.350	19.350	-1.68%
	5/17/2002				19.780	19.780	2.22%
	1/14/2004				19.730	19.730	-0.25%
	5/20/2005				19.800	19.800	0.35%
	11/17/2006				19.460	19.460	-1.72%
	5/9/2008				19.930	19.380	2.42%
	12/11/2009				19.200	19.200	-0.93%