NSP

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U S Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555

PRAIRIE ISLAND NUCLEAR GENERATING PLANT
Docket Nos. 50-282 License Nos. DPR-42
50-306 DPR-60

Supplemental Information on Programmable Logic Controllers
for the Station Blackout/Electrical Safeguards Upgrade Project
(TAC Nos. M68588 and M68589)

References: 1) Letter from Thomas M Parker, Northern States Power Company, to U S Nuclear Regulatory Commission dated November 27, 1990 titled "Design Report for the Station Blackout/Electrical Safeguards Upgrade Project"

2) Letter from Armando Masciantonio, U S Nuclear Regulatory Commission, dated June 6, 1991 titled "Request for Additional Information - Station Blackout/Electrical Safeguards Upgrade Project (TAC Nos. 68588/68589)

On November 27, 1990 we submitted for NRC Staff review the design report (Reference 1) for our project to add two additional safeguards emergency diesel generators, to upgrade the safeguards electrical distribution system, and to upgrade #121 Cooling Water Pump to become a swing safeguards pump.

On June 6, 1991 the NRC Staff requested additional information (Reference 2) regarding the load sequencers and the programmable logic controllers that comprise the load sequencers. We provided the information requested in a letter dated July 10, 1991. However, we also will utilize programmable logic controllers in the new 480VAC voltage regulators. Following discussion with the NRR project manager for Prairie Island, Armand Masciantonio, we agreed to respond to the same questions as applicable to the voltage regulator programmable logic controllers. Our response is attached to this letter.

In the attached response, we quote the 15 questions but replace the words "load sequencer" with "voltage regulator" wherever they appear.

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Please contact us if you have any questions related to the responses to the questions.

Thomas M Parker
Manager
Nuclear Support Services

c: Regional Administrator - Region III, NRC
Senior Resident Inspector, NRC
NRR Project Manager, NRC
J E Silberg

Attachments:
1. Response to Request for Additional Information
2. Voltage Regulator Programmable Controller Processor Specifications (7 pages)

ATTACHMENT 1

NORTHERN STATES POWER COMPANY
PRAIRIE ISLAND NUCLEAR GENERATING PLANT
STATION BLACKOUT/ELECTRICAL SAFEGUARDS UPGRADE PROJECT
RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

References:

1. "Design Report for the Station Blackout/Electrical Safeguards Upgrade Project", Northern States Power Company, November 27, 1990.

2. ANSI/IEEE-ANS-7-4.3.2-1982, "American National Standard, Application Criteria for Programmable Digital Computer Systems in Safety Systems of Nuclear Generating Stations".

QUESTION 1:

Provide the design information of the [Unit 1 &] Unit 2 [voltage regulator] programmable logic controller (PLC) (i.e., manufacturer, model number, etc.). Include in the description of the devices used in the [voltage regulators], the [voltage regulator] PLC programming language, compiler, type of microprocessors, etc.

RESPONSE TO QUESTION 1:

The voltage regulator uses an Allen-Bradley 1747-L511 SLC-500 Programmable Controller as the main processor. The programmable logic controller is provided with an EEPROM memory module for non-volatile storage of the application programs. Additional components of the voltage regulator programmable logic controller include:

1746-P1	Power Supply
1746-IA8	120 VAC 8 Point Input Module
1746-OW16	16 Point Relay Output Module
1746-OB8	8 Point Transistor Sourcing Module
1746-N14	4 Point Analog Input

Applicable product specification sheets are provided as Attachment 2 to this submittal.

The Allen-Bradley programmable logic controller was programmed using:

Allen-Bradley SLC-500
Advanced Programming Software
#1747-PAZE, Revision 2.01

This program is a tool to program the processor with the system ladder logic. The appropriate programmable logic controller commands are entered into the system as rungs of a ladder. This ladder logic format is read by the programmable logic controller and interpreted into programmable logic controller commands.

QUESTION 2:

NRC Regulatory Guide 1.152, which endorses ANSI/IEEE-ANS-7-4.3.2-1982 (Ref. 2), is not referenced in the Northern States Power Company (NSPC) submittal (Ref. 1). Provide documentation of the acceptance criteria for the [voltage regulator] system, and justify differences between the NSPC acceptance criteria and the Ref. 2 criteria.

Describe the plans for performing or reviewing the verification and validation (V&V) of the programmable logic controller (PLC) [voltage regulator] logic to be implemented on [Unit 1 &] Unit 2. If the V&V has been performed, provide the documentation of the V&V plan. If a V&V plan has not been developed, describe the process by which NSP will ensure the adequacy of the PLCs for 1E applications.

RESPONSE TO QUESTION 2:

The voltage regulator programmable logic controller system verification & validation (V&V) plan has been implemented in accordance with ANSI/IEEE-ANS-7-4.3.2-1982. A final V&V Report will be submitted to NSP which will summarize the results of the system validation testing and will show how the system is in compliance with the original system requirements.

QUESTION 3:

Describe the acceptance criteria for checking control cabinet instruments and control logic.

RESPONSE TO QUESTION 3:

The control cabinet instruments and control logic functions were fully tested during the V&V testing phases. This included module testing and integrated testing. The controlling function of the voltage regulator was verified by varying the input voltage between 310 VAC and 620 VAC and insuring that the output voltage remained within its desired range.

QUESTION 4:

Describe site acceptance/preoperational testing; specifically address loss and restoration of power to the PLCs during standby and power operation. Also describe the memory-retention capability of the PLC.

RESPONSE TO QUESTION 4:

Site acceptance testing of the voltage regulators will demonstrate that the system will respond correctly during varied input voltage conditions. The programmable logic controller logic will be functionally tested during the integrated preoperational testing of the new emergency diesel generators.

Upon loss of power to the programmable logic controller, an EEPROM memory

module installed in the programmable logic controller will contain a copy of the operating program which can be downloaded to the programmable logic controller memory on every power-up sequence. When power is restored to the programmable logic controller, the regulator will resume operation at that point.

QUESTION 5:

Provide the frequency at which the PLC [voltage regulator] algorithm will be tested, and discuss coordination of this testing with normal voltage regulator operations.

RESPONSE TO QUESTION 5:

Voltage regulator testing will take place during refueling outages and will be coordinated with 4160 VAC bus and 480VAC bus outages. The voltage regulator and the buses will be out of service during the testing, so that no coordination with normal voltage regulator operations is required.

QUESTION 6:

Describe the methods by which a loss of [voltage regulator] function is detected and mitigated, including the steps required to recover the voltage regulator function.

RESPONSE TO QUESTION 6:

The programmable logic controller processor contains a watchdog timer which will alarm if the programmable logic controller software does not complete a cycle in a predefined time period. In addition, the programmable logic controller logic will alarm on the loss of AC control power. The voltage regulator programmable logic controller is 'reset' by cycling AC power to the programmable logic controller. This action will perform a restart of the regulator.

QUESTION 7:

Provide the PLC Surge Withstand Capability (SWC) specifications, and justify the margin between the SWC and expected surges. Include the PLC power sources.

RESPONSE TO QUESTION 7:

The programmable logic controllers' logic power supply requires a 120VAC external source of power. This external 120VAC will be supplied from 120VAC uninterruptable power supplies which will provide a regulated and filtered source of power to the units.

According to Allen-Bradley product literature, the SLC-500 family of programmable logic controllers has been tested for noise immunity in

accordance with NEMA Publication ICS-2 Section ICS-2-230.

QUESTION 8:

Provide the PLC Electromagnetic Compatibility (EMC) specifications, and justify the margin between the EMC specifications and the electromagnetic interference.

RESPONSE TO QUESTION 8:

There are no strong sources of radio frequency interference (RFI) in the vicinity of Prairie Island which are not under plant control (such as commercial radio or television transmitters). A radio frequency interference survey of the control rod drive rooms conducted in 1985 confirmed this when levels less than 100 mV/meter were measured. Therefore, the source of objectionable radio frequency interference is primarily from the use of hand held walkie-talkies near susceptible solid state equipment.

To ensure that the programmable logic controllers within the voltage regulator are sufficiently immune to the expected electromagnetic interference at the Prairie Island site, the equipment will be tested for radiated and conducted susceptibility in accordance with SAMA Standard PMC 33.1-1978, and MIL Standard 461 and MIL Standard 462. MIL Standard Test Methods CS01, CS02 and CS06 will be the basis for the conducted susceptibility test. The Prairie Island site falls into Class 2 for radiated susceptibility as defined by SAMA Standard PMC 33.1-1978, since hand held transmitters are the primary source of objectionable electromagnetic interference. The equipment will therefore be tested for a 10 Volt/meter radiated field strength. An electromagnetic interference survey of the D5/D6 Building will be conducted to confirm this Class 2 field strength designation.

QUESTION 9:

Provide a detailed description of the device(s) used to accomplish electrical isolation between 1E and non-1E systems and describe the specific testing performed to demonstrate that the devices are acceptable for this application. This description should include elementary diagrams to indicate the test configuration and how the maximum credible faults were applied to the device(s).

RESPONSE TO QUESTION 9:

The only non-1E interface to the voltage regulator is the programmable logic controller trouble alarm output contact which is connected to the plant computer remote multiplexor unit. This alarm contact signal is generated by an isolated relay contact output from the SLC-500 output module. The same quality class of cable is used for alarm input connection as is used for the safety-related wiring in the plant. This wiring is also routed in control raceways which do not contain any power (480VAC or 4160VAC) circuits. The power supply associated with the remote multiplexor unit input is power

limited, and cannot deliver currents in excess of 2 to 3 amperes even with a bolted fault across the power supply output. The remote multiplexor input circuit is also protected with a 1.5 amp fuse which will further limit the fault current.

Based on the above, we have concluded that the programmable logic controller trouble alarm output contact is suitably isolated and protected, and no additional testing is required.

QUESTION 10:

Provide data to verify that the maximum credible faults applied during the test(s) discussed in Question #9 were the maximum voltage/current to which the device could be exposed, and define how the maximum voltage/current was determined.

RESPONSE TO QUESTION 10:

A discussion of the maximum credible fault on the non-1E remote multiplexor unit input is contained in our response to Question 9 above.

QUESTION 11:

Provide data to verify that the maximum credible fault was applied to the output of the device in the transverse mode (between signal and return) and to verify that other faults were considered (i.e., open and short circuits).

RESPONSE TO QUESTION 11:

A programmable logic controller relay-type output is used to isolate the non-1E alarm signal. There is no common return path between this alarm output and the other programmable logic outputs. Therefore, there is no transverse mode fault mechanism.

Short circuits are discussed in our response to Question 9. Because relay outputs are used as isolation devices, open circuits on the alarm wiring will not affect other programmable logic controller functions.

QUESTION 12:

Define the pass/fail acceptance criteria for each type of isolation device.

RESPONSE TO QUESTION 12:

See response to Question 9.

QUESTION 13:

Discuss the process by which NSPC will verify that the electromagnetic environment at the plant site is enveloped by the PLC manufacturer's EMC test parameters.

RESPONSE TO QUESTION 13:

As stated in our response to Question 8, an electromagnetic interference site survey will be conducted, and the results of this survey will be compared to the electromagnetic interference test intensities to ensure that the test envelopes the measured values.

QUESTION 14:

Describe the configuration control plan for the [Unit 1 &] Unit 2 [voltage regulator].

RESPONSE TO QUESTION 14:

During the software development and V&V testing phases, the configuration control of the programmable logic controller ladder logic and data files is administered by the voltage regulator vendor in accordance with their QA Manual and the verification and validation plan.

After the voltage regulator is delivered to NSP, responsibility for configuration control is transferred to the Electrical Systems Engineering group at the plant site. Control of the system will be accomplished in three areas and in accordance with the Prairie Island Quality Assurance Manual. First, any periodic testing will be done in accordance with the Surveillance Procedure program. Second, any troubleshooting - without changing ladder logic or data files - will be done in accordance with the Work Control program. Finally, any changes to the hardware or software will be done in accordance with the Uniform Modification Process, including 10CFR50 59 reviews.

QUESTION 15:

Provide the Mean-Time-To-Failure (MTTF) and the Mean-Time-To-Repair (MTTR) information for the PLCs.

RESPONSE TO QUESTION 15:

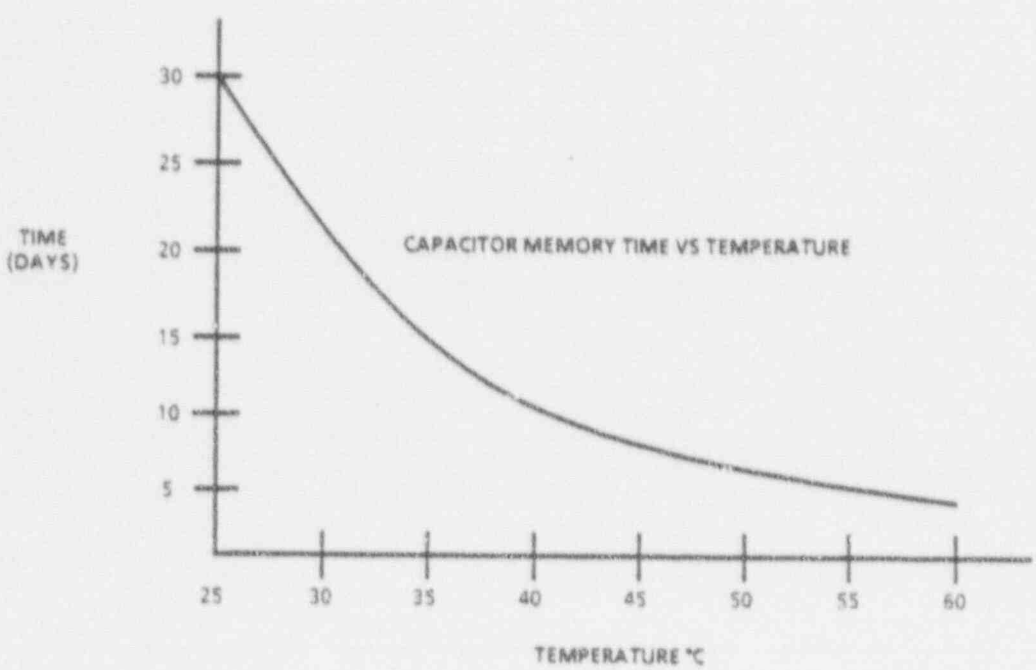
The Mean-Time-To-Failure (MTTF) is derived from Allen-Bradley calculations based on MIL-217D procedures. These calculations yielded an estimated MTBF range of 20,000 to 40,000 hours for the SLC-500 CPU, power supplies, racks, and I/O. The Mean-Time-To-Repair (MTTR) is the time required to replace the faulty module and return the voltage regulator to service, but does not include personnel mobilization time. This time to repair is one hour.

Chapter 6 Specifications

Specifications

SLC 5/01 CPU

DESCRIPTION	CATALOG NUMBER	
	1747-L511	1747-L514
Memory Type	Capacitor-backed RAM Memory Battery Back-up optional	Battery backed RAM standard
	Optional EEPROM and UVPROM memory modules available	
Power Supply Loading at 5 Volts DC	0.35 Ampere	
Power Supply Loading at 24 Volts DC	0.105 Ampere	
Capacitor Life	Refer to the curve below	None
Battery Life	5 years	2 years
Memory Size	1K Instruction Capacity	4K Instruction Capacity
Scan Time	10 milliseconds/1K (typical)	
Program Scan Hold-up Time after Loss of Power	20 milliseconds to 3 seconds (dependent on power supply loading)	
I/O Capacity	256 I/O points – 3 racks - 30 slots	
Noise Immunity	NEMA Standard ICS 2-230	
Ambient Temperature Rating	Operating: 0°C to +60°C Storage: -40°C to +85°C	
Humidity	5 to 95 % without condensation	



Specifications

Power Supplies

DESCRIPTION	CATALOG NUMBER 1746-P1	CATALOG NUMBER 1746-P2	CATALOG NUMBER 1746-P3
Line Voltage	85-132 / 170-265 Volts AC 50/60 Hz	85-132 / 170-265 Volts AC 50/60 Hz	19.2-28.8 Volts DC
Typical Line Power Requirement	135VA	180VA	90VA
Internal Current Capacity	2 Amperes at 5 Volts DC 0.46 Ampere at 24 Volts DC	5 Amperes at 5 Volts DC 0.96 Ampere at 24 Volts DC	3.6 Amperes at 5 Volts DC 0.87 Ampere at 24 Volts DC
User Current Capacity	24 Volts DC – 0.2 Ampere	24 Volts DC – 0.2 Ampere	–
Fuse Protection	3 Amperes	3 Amperes	5 Amperes
Ambient Operating Temperature Rating	0 to +55°C (Current capacity derated by 5% at +60°C)		
Humidity Rating	5-95% (non-condensing)		
Wiring	# 14 AWG		

Specifications

Input Modules

Catalog Number	Type	Points Per Module	Specifications
1746-IA4	100/120 Volts AC	4	On-State Voltage: 85-132 VAC Frequency: 47-63 Hz Off-State Voltage: 30 VAC (maximum) Nominal Input Current: 12mA at 120 VAC Turn-On Time: 35 msec. (maximum) Turn-Off Time: 45 msec. (maximum) Maximum Off-State Current: 2mA
1746-IA8		8	
1746-IA16		16	
1746-IM4	200/240 Volts AC	4	On-State Voltage: 170-265 VAC Frequency: 47-63 Hz Off-State Voltage: 50 VAC (max.) Nominal Input Current: 12mA at 240 VAC Turn-On Time: 35 msec. (maximum) Turn-Off Time: 45 msec. (maximum) Maximum Off-State Current: 2mA
1746-IM8		8	
1746-IM16		16	
1746-IB8	24 Volts DC Sink & Source	8	On-State Voltage: 10-30 VDC Off-State Voltage: 5 VDC (maximum) Nominal Input Current: 8 mA at 24 VDC Turn-On Time: 8 msec. (maximum) Turn-Off Time: 8 msec. (maximum) Maximum Off-State Current: 1mA
1746-IB16		16	
1746-IV8		8	
1746-IV16		16	
1746-IG16	5 Volts DC	16	Low-True / Sourcing, Schmitt Trigger User Supplied Voltage: 4.5 to 5.5 VDC, 50 mV p-p ripple maximum On-State Voltage: -0.2 to +0.8 VDC Off-State Voltage: 2.0 to 5.5 VDC User Supplied Current: 175mA maximum at 5 VDC Nominal Input Current: 3.7mA Turn-On Time: 0.25 msec. (maximum) Turn-Off Time: 0.50 msec. (maximum) Maximum Off-State Current: 4.1mA

Specifications

Output Modules

Catalog Number	Type	Points Per Module	Specifications	
1746-OA8	120/240 Volts AC Triac	8	On-State Voltage:	80-265 VAC
			Maximum On-State Voltage Drop:	
			1746-OA8	1.5 Volts (maximum) at 1 Ampere
			1746-OA16	1.5 Volts (maximum) at 0.5 Ampere
			Frequency:	47-63 Hz
			Continuous Current (per output):	
			1746-OA8	1 Ampere at +30°C 0.5 Ampere at +60°C
			1746-OA16	0.5 Amp at +30°C 0.25 Ampere at +60°C
1746-OA16		16	Continuous Current (per module):	8 Amperes at +30°C 4 Amperes at +60°C
			Minimum Load Current:	10mA
			Surge Current (per output):	10 Amperes for 25 msec. recurring once per second maximum at +30°C 10 Amperes for 25 msec. recurring once every two seconds maximum at +60°C
			Turn-On Time:	0.1 msec. (maximum)
			Turn-Off Time:	11 msec. (maximum)
			Maximum Off-State Leakage Current:	2mA
1746-OB8	24 Volts DC Source	8	Output Voltage:	0-50 VDC
			Maximum On-State Voltage Drop:	1.2 Volts maximum at 1 Ampere
			Continuous Current (per output):	1 Ampere at +30°C 0.5 Ampere at +60°C
			Continuous Current (per module):	8 Amperes at +30°C 4 Amperes at +60°C
			Minimum Load Current:	1mA
			Surge Current (per output):	3 Amperes for 10 msec. recurring once per second maximum at +30°C 3 Amperes for 10 msec. recurring once every two seconds maximum at +60°C
			Turn-On Time:	0.1 msec. (maximum)
			Turn-Off Time:	1.0 msec. (maximum)
			Maximum Off-State Leakage Current:	1mA

Specifications

Output Modules

Catalog Number	Type	Points Per Module	Specifications
1746-OG16	5 Volts DC	16	Low-True / Sinking, Schmitt Trigger User Supplied Voltage: 4.5 to 5.5 VDC, 50mV p-p ripple maximum User Supplied Current: 495mA maximum at 5 VDC Continuous Current (per output): 24mA Minimum Load Current: 0.15mA Turn-On Time: 0.25 msec. (maximum) Turn-Off Time: 0.50 msec. (maximum) Maximum Off-State Current: 0.1mA
1746-OV8	24 Volts Sink	8	Output Voltage: 10-50 VDC Maximum On-State Voltage Drop: 1746-OV8: 1.2 Volts (maximum) at 1 Ampere 1746-OV16: 1.2 Volts (maximum) at 0.5 Ampere Continuous Current (per output): 1746-OV8: 1 Ampere at + 30°C, 0.5 Ampere at + 60°C 1746-OV16: 0.5 Ampere at + 30°C, 0.25 Ampere at + 60°C Continuous Current (per module): 8 Amperes at + 30°C, 4 Amperes at + 60°C Minimum Load Current: 1mA Surge Current (per output): 3 Amperes for 10 msec. recurring once per second maximum at + 30°C; 3 Amperes for 10 msec. recurring once every two seconds maximum at + 60°C Turn-On Time: 0.1 msec. (maximum) Turn-Off Time: 1.0 msec. (maximum) Maximum Off-State Leakage Current: 1mA
1746-OV16	24 Volts Sink	16	
1746-OW4	Relay (See footnote ① on Page 6-6)	4	Output Voltage: 5-265 VAC, 5-138 VDC Continuous Current (per output): 1746-OW4 & 1746-OW8: 2.0 Amperes 1746-OW16: 1.0 Ampere Turn-On Time: 10 msec. (maximum) Turn-Off Time: 10 msec. (maximum) Maximum Off-State Leakage Current: 0mA
1746-OW8	Relay	8	
1746-OW16	Relay	16	

Maximum Volts	Amperes Make	Amperes Break	Amperes Continuous	Voltamperes Make	Voltamperes Break
240VAC	7.5A	0.75A	2.0A	1800VA	180VA
120VAC	15A	1.5A	2.0A	1800VA	180VA
125VDC	0.22A		1.0A	28VA	
24VDC	1.2A		2.0A	28VA	

Catalog No. 1746-NI4 Analog Input Module

DESCRIPTION	SPECIFICATION
GENERAL	
Input Channels per Module	4 differential, voltage or current selectable per channel, not individually isolated
Field Wiring to Backplane Isolation	500 Volts DC
Backplane Power Consumption	25mA at 5 Volts DC 100mA at 24 Volts DC
Update Time	512µs. for all channels in parallel
SLC Communication Format	16 Bit Two's Complement Binary
Calibration	Factory Calibrated
Environmental Conditions Operating Temperature Storage Temperature Relative Humidity	 0 to +60°C -40°C to +85°C 5-95% (non-condensing)
Terminal Block	Removable
Maximum Wire Size	#14 AWG
Recommended Cable	Belden #8761
Location	1746 Rack
INPUT GENERAL	
Converter Resolution	16 Bit
Location of LSB in I/O image word	0000 0000 0000 0001
Non-linearity	0.01%
Common Mode Voltage Range	-20 Volts DC to +20 Volts DC
Common Mode Rejection at 0 to 10 Hz (minimum)	50dB
Common Mode Rejection at 60 Hz (minimum)	115dB
Normal Mode Rejection at 60 Hz (minimum)	55dB
Channel Bandwidth	10 Hz
Settling Time ①	60 milliseconds
Conversion Method	Delta-Sigma Modulation
Voltage Input Coding (-10VDC to +10VDC - 1LSB)	-32768 to +32767
Current Input Coding (-20mA to +20mA) (-30mA to +30mA)	-16384 to +16384 -24576 to +24576

① Refer to Page 3-12.

Catalog No. 1746-NI4 Analog Input Module

DESCRIPTION	SPECIFICATION
CURRENT MODE INPUT Full Scale = 20mA Vcm = 0	
Input Range (Normal Operation)	-20mA to + 20mA
Absolute Maximum Input Current	± 30mA
Absolute Maximum Input Voltage	± 7.5 Volts DC or 7.5 Volts AC RMS
Input Impedance	250 Ohms
Resolution	1.22077μA per LSB
Overall Accuracy (at + 25°C maximum)	± 0.365% of full scale
Overall Accuracy (0 to + 60°C maximum)	± 0.642% of full scale
Overall Accuracy Drift (maximum)	± 79ppm/°C of full scale
Gain Error (at + 25°C maximum)	± 0.323% of full scale
Gain Error Drift (maximum)	± 67ppm/°C of full scale
Offset Error (at + 25°C max.) (Iin = 0, Vcm = 0)	± 7 LSB
Offset Error (0 to + 60°C max.) (Iin = 0, Vcm = 0)	± 14 LSB
Offset Error Drift (maximum) (Iin = 0, Vcm = 0)	± 0.2 LSB/°C
VOLTAGE MODE INPUT Full Scale = 10 Volts Vcm = 0	
Input Range	-10 Volts DC to + 10 Volts DC - 1LSB
Input Impedance	1Mohm
Resolution	305.176μV per LSB
Overall Accuracy (at + 25°C maximum)	± 0.284% of full scale
Overall Accuracy (0 to + 60°C maximum)	± 0.504% of full scale
Overall Accuracy Drift (maximum)	± 63ppm/°C of full scale
Gain Error (at + 25°C maximum)	± 0.263% % of full scale
Gain Error Drift (maximum)	± 57ppm/°C of full scale
Overvoltage Protection (maximum across IN + to IN - terminals)	220 Volts AC RMS continuously
Offset Error (at + 25°C max.) (Vin = 0, Vcm = 0)	± 7 LSB
Offset Error (0 to + 60°C max.) (Vin = 0, Vcm = 0)	± 14 LSB
Offset Error Drift (maximum) (Vin = 0, Vcm = 0)	± 0.2 LSB/°C