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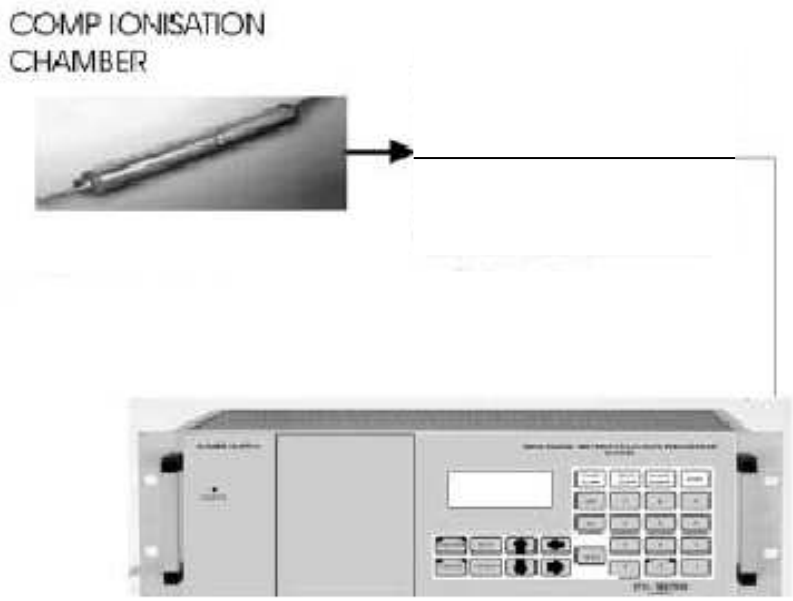
Power Controller Assembly

NFA-06.08



Contents

1. Power Controller Assembly NFA-06.08

Features:

- Detectors: fixed position fission chamber and compensated ionisation chamber
- 10^{-9} to 10^{-3} A detector current
- Manual, automatic mode
- Special DDC algorithm for automatic control
- Self testing capability

The NFA-06.08 Power Controller Assembly can be used for manual and automatic control of the power level of a nuclear reactor on the base of the neutron flux level. The equipment can also be used in intermediate and power range for neutron flux monitoring channel.

2. General description

In the steady state the reactor is critical when the effective multiplication factor k is equal to1. To increase or decrease the power level of the reactor requires that k be increased or decreased above or below of unity during the interval when the power level is changing. Once the desired power level has been reached, k must be restored to unity so the reactor can again operate in steady state, at the new power level.
Rods containing neutron absorption material control most nuclear reactors. Rods are inserted into (k factor decreased) or withdrawn from (k factor increased) the reactor core. In reactors that are inherently stable, it is necessary preferable, for an operator to keep the power at a demand level by adjusting the control rod position. An automatic reactor control system the power demand signal is compared with the measured neutron level, and the reactivity is adjusted by programming the rod control actuators to increase or decrease reactor power.
There are two standard reactor operating modes: manual or automatic.
The manual and automatic reactor control modes are used for reactor from intermediate level to 100 % power.

3. Operation

Components of the NFA-06.08 Power Controller Assembly:

- Compensated ion chamber probe with max. 200m long cable.
- NFL-03.09 Picoammeter.
- NFA-05.06C Current Range Neutron Flux Data Processor (CR-NFDP).
- DCL-05 Keyboard & Display.
- Control rod driver (optional)

4. Detector

4.1. Compensated Ionisation Chamber Probe

The detector KNK-53M is a ^{10}B lined, gamma compensated ionisation chamber for detection of thermal neutrons in a flux range of 10^4 to $5*10^{10}$ nv. During out-of-core measurement neutrons are to be detected in the presence of a strong gamma field, and as a consequence the ionisation current caused by gamma radiation exceeds the current originating from neutrons. In a compensated ionisation chamber a second ionisation chamber detecting only gamma is placed as Cell. The signal from the gamma chamber (gamma sensitivity is $1,5*10^{-12}$ A/r/H) may be used to cancel the gamma contributions to the neutron chamber signal (neutron sensitivity $4*10^{-14}$ A/nv). The probe is design and constructed from materials that minimise the effects of activation.

5. Analog Module

5.1. Picoammeter Module NFL-03.09

- Measuring range: 10^{-11} to 10^{-3} A (in 8 ranges)
- Neutron flux measurement in intermediate and power ranges
- High voltage generators: included (positive and negative)
- Computer interfacing:
    - Multiline: analogue and digital signals Without intelligence.
    - RS 485 serial I/O
- Powered from single power supply

The Picoammeter Module NFL-03.09 receives the signal of compensated ion chamber probe.

The current from an ionization chamber, with the values of 10^{-11} to 10^{-3} A, is fed to the equipment through a coaxial cable. The module with 8 switchable ranges converts detector signal into a measurement current of 0/4…20 mA. The range switching is accomplished by automatic or manual manner, depending on the state of AUT/MAN signal. In manual state the range is controlled by RANGE UP or RANGE DOWN binary signals controlled electronic stepping-switch system.
The positive and negative HV power supplies are built up of encapsulated circuits surrounded by current-loop driven isolated set-value controls and HV-monitoring isolation amplifiers. Both set-value control signals (HV+CNTR and HV-CNTR), and monitoring signals (HV+MON and HV-MON) are controlled by means of current loops.
The primary supply of power enters the board. Transient protection from the outside world is done by fuse diode. It saves the inputs of a four-member group of isolated DC-DC converters from damages.

6. Power Controller- Neutron Flux Data Processor (PC-NFDP) NFA-05.06C

The signals from compensated ion chamber module are further processed in the Current Range Neutron Flux Data Processor (CR-NFDP).
Components of the CR-NFDP:

1. NFL-03.09 Picoammeter;
2. NFI-08.18 Picoammeter interface module
3. NFI-08.15 Main processor module;
4. DCL 05 keyboard & display board;
5. Low voltage power supply.

The modules are situated in a 19" rack. On the front panel the operator interface is accomplished via DCL 05 keyboard & display board. The power switch, SERVICE lock switch, mains connector and fuse are on the back panel. The CONTROL DESK and MOTOR CONTROL connectors are on the main processor unit. An RS 485 connector and other organs that are important from the point of view of usage are placed on the back panel. In addition, there are still several terminals on the back panel, which are mainly important on servicing.
Analog and digital lines carry out the signal exchange between analog modules and PC-NFDP. For analogue signal exchange 0/4…20 mA decoupled current loop signals are used because nearly interference frees transmission. For digital signal exchange potential free relay contacts ensures the decoupling. The frequency and serial interface signals are transmitted and decoupled according to RS485A standard.

Features:

1. Linear level from 10^{3} to 10^{11} nv is measured in sixteen ranges. In this multirange function the equipment converts the DC power signal into 16 linear power ranges. This feature provides precise reading of linear power level over the 8 decade of reactor power. The multirange function is auto range.
2. Processor creates a power reference signal.
3. Controls the reactor power in automatic operation mode,

The A/D converter receives current and range signals and of NFL-03.09 module.
Digital outputs control the test generator, the range of the DC amplifiers and the operating mode.
Interface lines control and the output voltage of high voltage power supplies.
Watchdog unit supervises the proper operation of the whole digital processing hardware. An operating status signal (WORK) shows if the program goes to a wrong path or the self-monitoring system shows malfunction situation. The WORK lamp shows the state of the watchdog unit.

The unit shall be provided with a data acquisition module. The DAS module shall acquire the analog data & digital data from each analog modules related to power readings, individual alarms, EHT failure, EHT voltage, etc. The power and power rate shall be displayed as trend graphs also.
The DAS shall record the data at regular interval in a local storage media. The interval shall vary from 1 ms to 1 min. It shall also record the alarm status including the instances of alarm generation and restoration to normal state. During the alarm condition, the recording interval shall be short so that data is not lost. The monitor shall retain data for at least the previous 24 hours at any time. In case of an alarm, the data preceding to the alarm, during the alarm and after the alarm shall be retained and not overwritten. The data in memory shall be provided through Ethernet port to a remote PC on demand. The protocol shall be based on Modbus. The recording intervals shall be as follows:

Preceding the accident	: 0.1 s.
During first 10 seconds after criticality has been detected	: 0.1 s
During the next 100 secs.	: 1 s.
During the next 1000 secs.	: 10 s.

The DAS module shall be provided with an Ethernet 10/100 Mbps port for interfacing with a remote IBM PC-compatible computer. The PC and the instrument shall operate in a host-slave configuration and the software protocol shall be Modbus/TCP or Modbus/RTU. The PC as the host shall give commands and send queries. The monitor shall carry out the various functions as per the required information in response to the queries.

The firmware of the instrument shall be able to send the instrument data like Instrument ID, Instrument type, alarm settings, alarm status, current reading, and diagnostic status of EHT etc. to the Host PC on demand. The firmware shall also send the history data for at least the last 24 hours on demand. Detailed list of the command and response for the Host-slave communication will be provided by the user.

Primary function of the module, in addition to the mentioned level excess monitoring, is to establish man-machine connection, and to produce accessibility of the measured data via a serial interface.
Operator interface is accomplished via a 4x20 character wide vacuum fluorescent display and a keyboard of 23 push buttons. In LOCAL mode by means of the keyboard one can control the operation of the whole channel, set measuring range, changing display picture, controlling test, power etc. In remote mode the trip reset and range control can be realised through REMOTE rear panel connectors.
Functional capabilities are testing during reactor operation and during outages because the entire system is self-monitored. All adjustable parameters of the neutron monitoring assembly, like high voltage value, power factor, etc. are testing periodically. Failures or deviations from reselected values are indicated immediately.

7. Technical data

7.1. Compensated Ion Chamber Probe

Detector Type	KNK-53M
Measuring range	10^{3} to 5 x 10^{10} nv
Manufacturer	Russia
Detector/compensation voltage	+ 500 V/ - 500 V adjustable
Neutron sensitivity	4 x 10^{-14} A/nv
Gamma sensitivity	1,5 x 10^{-12} A/R/h
Length	472 mm
Diameter	70 mm
Operating temperature	- 40 to + 400 °C

7.2. NFL-03.09 Picoammeter

1. Picoamper meter

Isolated input	Isolation voltage: 500V max.
Offset voltage	5 mV max. at 25 C° 0,05 mV/ C° max.
Bias current	10^{-12} A max. at 25 C°
Input resistance	10 kΩ

Input ranges

Range [A]	Accuracy (RTM) [%]	Temperature coefficient [/C°]	Settling Time Filtered output [ms]	Settling Time Direct output [ms]
10^{-10}	±1	0,05 %	1000	< 5 ms
10^{-9}	±0,5	0,05 %	200	< 5 ms
10^{-8}	±0,3	0,03 %	80	< 5 ms
10^{-7}	±0,2	0,02 %	15	< 5 ms
10^{-6}	±0,2	0,02 %	7	< 5 ms
10^{-5}	±0,2	0,02 %	7	< 5 ms
10^{-4}	±0,2	0,02 %	6	< 5 ms
10^{-3}	±0,2	0,02 %	6	< 5 ms

Range control input	
-Number	3 (RANGE UP, RANGE DOCN, AUT/MAN)
- Levels	-33 to 8 V logic 0 13 to 72 V logic 1
- Isolation	500VDC, 230VAC(between input and internal ground)
Range overlapping failure	< 1 % (RTM)
- Dead time after switching range	10 ms
Analog output	
- Output range	0/4 to 20 mA
- Accuracy	± 1 % (T=25°C, related to end value)
- Voltage test	500 V AC (between output and housing)
- Nonlinearity	< 2 x 10^{-3} (related to end value)
- Temperature coefficient	Max. 10^{-4} / K
Output select input	
- Levels	-33 to 8 V logic 0 (direct output) 13 to 72 V logic 1 (filtered output)
- Isolation	500VDC, 230VAC(between input and internal ground)
- Dead time after selecting output	20 ms

2. High voltage power supply

High voltage setting range (detector)	0 to + 500 V / max. 1 mA
High voltage setting range (Gamma compensation)	0 to - 500 V / max. 1 mA
Ripple	Max. 100 mV_{pp}
Temperature effect	Max. 2 x 10^{-4} / K
Load effect	Max. 10^{-4} / 0.3 mA
HV setting	Through 0/4 to 20 mA current loop
HV monitoring	Through 0/4 to 20 mA current loop

3. Communication

Interface	Isolated RS485A
Rate	57.6 kbaud
Protocol	ANSI-0
Length	Max. 100 m..

4 Further Data

External power	
- Nominal value	24 V DC
- Deviation	18 to 33 VDC
Operating conditions	
-Ambient temperature	10 to + 55 °C
-Relative humidity	Max. 90 %

7.3. Neutron Flux Data Processor

1.Analog Inputs

- Signals	Signals from NFL-03.09 Picoammeter Current Signal Current Range Signal
- Range	0/4 to 20 mA
- Resistance	75 Ω
-Isolation	500VDC, 230VAC
- Accuracy	± 1 % (T=25°C)

2. Digital Outputs

-Characteristics	Isolated relay contact pairs Contact rate: 50 V/100 mA Isolation: 300 V

5. Remote connector

5.1 Digital Inputs

- Characteristics	Opt isolated Voltage / current: 5 V/20 mA Isolation voltage: 300 V dc

5.2 Analog outputs

- Functions	LIN POWER: multirange analog signal LIN POWERRANGE: range signalisation
- Characteristics	Isolation: 300 V dc Current range: 4…20 mA Load resistance: max 500 'Ω Accuracy: ± 1 %

7.4. DCL-05 Keyboard & Display

1.	**Display** Displayed values	4x20 characters VFD DC channel range & current level Power(W) High voltage levels: HV+, HV- Operating status: measuring, test Channel control mode: remote, local.
2.	**Keyboard**	23 push buttons • Numeric characters: 0…9, ±, .,exp • ENTER • Clear enter (CE) • Select (→, ←) • Increase (↑) • Decrease (↓) • Display select (PAGE UP, PAGE DOWN) • REMOTE/LOCAL • WORK/TEST
3.	**Indicator lamps**	• WORK

7.5. General

Mains	220 V +10 % - 15 %, 50 Hz, max. 100 VA.
Dimensions	Width: 19" (481 mm). Height: 3U (177mm). Depth: 440 mm.
Ambient temperature	10.to.40 °C
Relative humidity	max 90 %
Mass	10 kg

8. Block diagram