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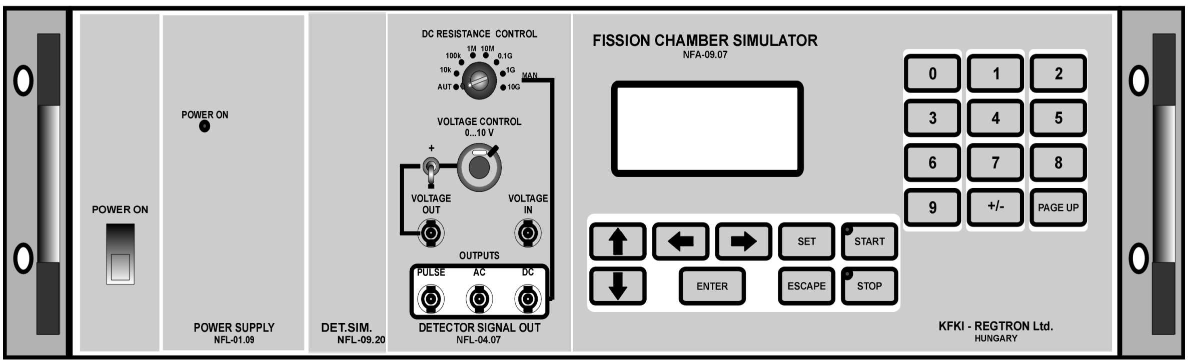
Fission Chamber Simulator
NFA-09.07



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1 Introduction

The NFA-09.07 Programmable Generator (FCS) is very useful at the calibration of nuclear channels. FCS outputs signals are similar to the nuclear detectors, and it is equipped with programs, making possible to generate different signals necessary for testing, troubleshooting individual elements of the neutron level measurement chain of nuclear instruments. By the aid of this instrument the neutron flux interacted fission chamber put can be simulated very easily. It means that after the reactor and detector parameters are set accurately the signals appear at the pulse, ac and dc outputs follow very well the signals of a real detector.
To accomplish this aim FCS produces adjustable test signal levels in the 1.00E+00 to.1.00E+11 nv range on its three outputs (PULSE, AC, DC) according to the diagrams attached to this description (Fig. 1 to Fig. 4). It also calculates the nominal power in % (Fig. 5).
The neutron flux time behaviour is either constant or changing exponentially. It means that except of stable state can evoke increase or decrease between two pre selected level value exponentially with a time constant of T.PER (period time) (Fig. 6).
Operating parameters of FCS can be set by using the 21-key pad and Vacuum Fluorescent Display (VFD) on the front panel. At the same time PC-control of the generator via an RS232 serial link is also possible.

The FCS can be characterized as a programmable pulse generator consisting of

Detector Simulator module	NFL-09.20
Detector Signal Output module	NFL-04.07
Terminal module	DCL-01.13
Power Supply	NFL-01.09

2 Principle of Simulation

The nuclear reactor is simulated by an internal generator. This generator calculate the temporally value of neutron flux in nv unit. In most reactors the dynamic range of neutron flux is 1.00E+00 to 1.00E+11 nv in detector position.
Parameters of detector signals depend on the level of neutron flux. In pulse regime the frequency in ac regime the amplitude of ac current in dc regime the amplitude of dc current follows the nv value according to the following:

1. In **pulse** regime the frequency of simulated signal depends on the currently neutron flux according to the following:

   $f_{PULSE} = K1 * \Phi$
   where

f_{PULSE}	nominal frequency of pulse output	[Hz]
K1	pulse sensitivity of simulated detector	[Hz/nv]
Φ	simulated neutron flux	[$nv=N/m^2 \times s$]

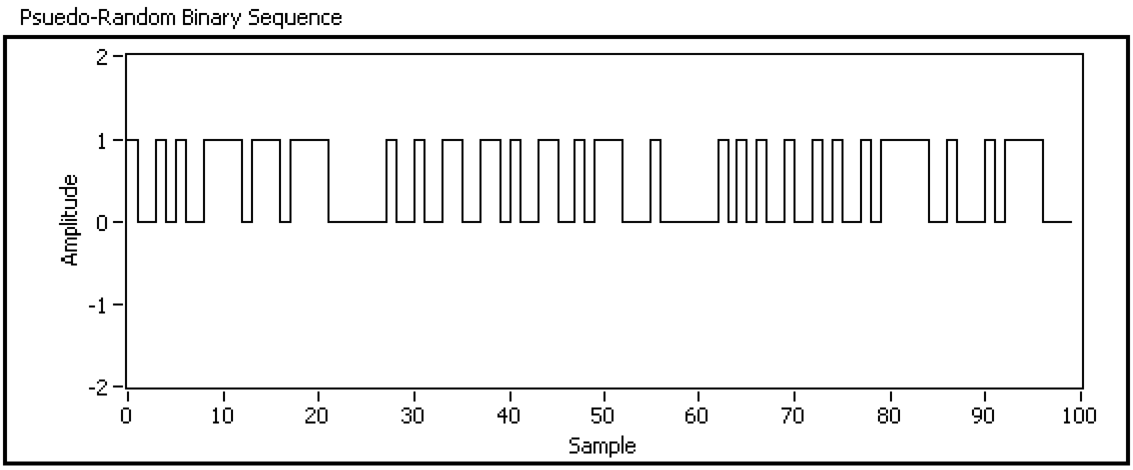
   The higher corner point of pulse frequency- neutron flux characteristics (PFLUX1 in Fig. 2) represents the pulse overlapping effects. It means that -depending of the collection time of detector- the output frequency saturates and not able increase its output frequency any more. The amplitude and width of pulses are constant during start period of simulation. FCS allows to set 2 width (0.1 µs/1.5 µs) and 2 amplitude (20 mV/200 mV). The frequency of puse signal is either constants (noiseless) or stochastically changes (noisy).The stochastic signals are generated in digital manner. The frequency spectrum of stochastic signals has the following components:
   $2 f_0$ with 0.5 relative weight,
   f_0 with 0.25 relative weight,
   $f_0/2$ with 0.125 relative weight, etc.

2. In **ac** regime the amplitude of simulated ac current signal depends on the currently neutron flux according to the following:

$I_{AC} = K2 * \sqrt{\Phi}$
where

I_{AC}	nominal rms current at ac output	[µA]
K2	ac sensitivity of simulated detector	[µA /√nv]
Φ	simulated neutron flux	[nv=N/m^2 x s]

The frequency of ac signal is either constants (noiseless) or stochastically changes causing fluctuation in amplitude (noisy).The stochastic signals are generated in digital manner. A Pseudo-Random Binary Sequence is a periodic, deterministic signal with white-noise-like properties. They are generated using an n bit shift register with feedback through an exclusive-OR logic. While appearing random in actually the sequence repeats every 2^n-1 values. In particular, variations in response signals between two periods of the stimulus can be attributable to noise due to the periodic nature of the signal. Also, like white random binary noise it has an optimal crest factor.



The lower corner point of current- neutron flux characteristics (AFLUX0 in Fig. 3) represents the summarized non neutron generated noise (originating in electronic and detector). It means that - depending of the non predicted noise signal the output current saturates and not able to decrease its amplitude any more.

3. In **dc** regime the amplitude of simulated current signal depends on the currently neutron flux according to the following:

$I_{DC} = K3 * \Phi$

where

I_{DC}	nominal current of dc output	[µA]
K3	dc current sensitivity of simulated detector	[µA /nv]
Φ	simulated neutron flux	[nv=N/m^2 x s]

The lower corner point of current- neutron flux characteristics (DFLUX0 in Fig. 4) represents the summarized non neutron generated current (originating in electronic and detector). It means that the output current saturates and not able to decrease its amplitude any more. The higher corner point of current- neutron flux characteristics (DFLUX1 in Fig. 4) represents the saturation of neutron generated current. It means that the output current saturates and not able to increase its amplitude any more.

3 Operation

Operation is explained by the aid of the block diagram (see it on the following page).
The FCS consists of two galvanically separated parts: the first part holds the signal generation's digital functions while the second one contains the output functions. Signal traffic between these parts is affected via optocoupler.

3.1 Microcontroller Firmware

Functional block, labelled as dsPIC Microcontroller refers to a RISC-architecture microcontroller type which owns all the features needed to implement the technical specification. It has a high operating speed, hardware-implemented multiplier/divider, 16-bit timers, asynchronous UART, versatile interrupt mechanism and individually oriental I/O pin drivers. All of the functions of the digital parts are controlled by a microcontroller (dsPIC). Among them the Digital Clock Generator (DCG) and the binary Pseudo Noise Generator (PNG), driven by DCG, have leading roles. DCG produces programmable frequency clock signals for PNG in the 1 Hz to 2 MHz range with 0.1 Hz resolution. PNG produces two signal series at its outputs which have a time spectrum very similar to the real nuclear detector signals. One of them results the control of the PULSE signals, and the other of the AC signals.The most important part of the firmware is the method to produce the exponentially increasing or decreasing output levels in time. The firmware issues a new set of operating parameters at constant time increments [e.g. in every 100 ms] which approaches a best fit to the exponential output, [constant time increment method].

The firmware's backbone is a command interpreter which acts as a mechanism to interpret the set-up parameters, entered by the operator either from a PC terminal or from the built-in 21-key keypad + VFD combination (serial I/O interfacing).
After having collected the necessary set of parameters from the mentioned inputs, the firmware enters into the generating phase: it starts sending control sequences to the controlled blocks according to the prescribed time and level requirements.
The signal conditioning part is controlled through isolated digital signals. Those are to control of 3 digital-analogue converters, 2 timing signals for pulse and ac outputs, and 3 for controlling dc output resistances.

3.2 PULSE output

The PNOUT1 signal triggers the programmable monostable multivibrator. The output signal of MMV (PULSE OUT) controls a fast analogue switch (AN MPX), connecting the upper side of the PULSE output's resistive divider chain alternately to a REF PULSE level and GND. This voltage signal is led through the polarity control stage to the PULSE output. A 20 kΩ external resistor converts the voltage to current.

3.3 AC output

The PNOUT2/AC_OUT signal controls a fast analogue switch (AN MPX), connecting the upper side of the AC OUT alternately to a REF AC level and GND. A 200 kΩ external resistor converts the voltage to current.

3.4 DC output

The current level of DC OUT can be determinate by the aid of internal or external voltage source and of the choice the sufficient internal resistor. This instrument can implement only noiseless current source.
The current level can be set automatically and manually. The required control mode can be set by an 8 positions switch to be found on the front panel of NFL-04.07.

- If the RESISTANCE CONTROL switch is in "Aut" position, both the resistance and voltage setting is going on automatically. In this regime the voltage of DAC 3 is lead to the input of 7 tag resistance network. Also automatically is choice the optimal resistance value.
- If the RESISTANCE CONTROL switch is in any of the 10 kΩ, 100kΩ, 1 MΩ, 10 MΩ, 100 MΩ, 1 GΩ, 10 GΩ, positions, the labelled resistance connects to the DC output. In this regime the voltage of VOLTAGE IN input is lead to the input of 7 tag resistance network. The voltage setting is going on manually. In most cases the VOLTAGE OUT is connected to VOLTAGE IN connector. A font panel potentiometer controls the voltage level in the range of 0 to 10 V.

3.5 Control terminal

The control terminal serves for

1. Setting the simulator parameters.
2. Displaying the current value of computed parameters.
3. Choosing the required page.
4. Start/stop functions.

There are 21 knobs, 2 LED-s, a VF display with 4x20 characters to ensure the man-machine interfacing.
The control panel has its own microcontroller in order to sove the tasks mentioned above. The microcontroller has a serial I/O stage to ensure data flow between dsPIC and the panel.

3.6 PC interfacing

Communication between the Simulator and its control-PC is based on a **full-duplex, 57.6 kBaud** serial channel, using a simple, single-character protocol, corresponding to the **MASTER-SLAVE** relation, where the Slave is the Simulator, while the Master is always the PC. The serial communication is taking place through RS 232 back panel connector.

3.6.1 Parameter table

Parameter table is maintained in Simulator. This table contains all parameters dealing with Firmware Processor (FP) communication. Because the number of parameters exceed 20, it turned out better using an indirect addressing system for them, i.e. instead of having a single character for identifying a parameter's place in the Simulator's memory, an ADDRESS and a VALUE mailbox is used to write them one-by-one. The ADDRESS is a relative index, pointing to the actual parameters relative place in the table, while VALUE is its actual value to be written into this address. After having placed a new parameter into this mail-box, issuing a 'W' command will write it to its place. The following table shows all programmable parameters and its relative addresses.

Table1

ADDRESS	Designation	Parameter description
1	-	-
2	PFLUX1	The upper corner point of PULSE output in terms of [nv]
3	AFLUX0	The lower corner point of AC output in terms of [nv]
4	-	-
5	DFLUX0	The lower corner point of DC output in terms of [nv]
6	DFLUX1	The upper corner point of DC output in terms of [nv]
7	FLUX0	The lower final value of simulated neutron flux in terms of [nv]
8	FLUX1	The higher final value of simulated neutron flux in terms of [nv]
9	K1	Pulse sensitivity in terms of [pps/ nv]
A	K2	AC sensitivity in terms of [µA/√nv]
B	K3	DC sensitivity in terms of [µA/nv]
C	K4	Power factor of reactor in terms of [%/nv]
D	ACFREQU	Nominal frequency of AC output signal in terms of [kHz]
E	T.PER	Exponential variable neutron flux time constant in terms of [s]
F	STATUS	Status expression in terms of bites****
10	PFREQU	Momentary value of PULSE output in terms of [pps]
11	ACURR	Momentary value of AC ouput in terms of [µA]
12	DCURR	Momentary value of DC output in terms of [µA]
13	FLUX	Momentary value of simulated neutron flux in term of [nv]
14	FH	Setting of the momentary frequency of PULSE output signal*
15	AC	Setting of the momentary amplitude of AC output signal**
16	DC	Setting of the momentary amplitude of DC output signal***

* The form and meaning of **FH** parameter value

ppppqqqq

- pppp period time, (settable range: 2 to 65536)
- qqqq multiplication factor. Settable range 0..1 közötti értékeket vehet fel, (ha 0001..FFFF ill. 0000..7FFFközötti HEX-értéket adunk meg).

****** The form and meaning of **AC** parameter value

ppppaaaa

- pppp period time, (settable range: 2 to 65536)
- aaaa amplitude, (settable range: 0000 to FFFF)

******* The form and meaning of **DC** parameter value

xxxxaaaa

- xxxx value with no meaning
- aaaa amplitude, (settable range: 0000 to FFFF)

**** Status

<table>
<tr><td></td><td>0</td><td>1</td><td colspan="2">Notes</td></tr>
<tr><td>B14</td><td>STOP</td><td>START</td><td colspan="2"></td></tr>
<tr><td>B13</td><td>FRONT-PANEL</td><td>PC-COMx</td><td colspan="2">The way of inputing parameters</td></tr>
<tr><td>B12</td><td>0.1 µs</td><td>1.5 µs</td><td colspan="2">PULSE WIDTH</td></tr>
<tr><td>B11</td><td></td><td></td><td colspan="2"></td></tr>
<tr><td>B10</td><td>AUT</td><td>MAN</td><td colspan="2"></td></tr>
<tr><td>B9</td><td>CONST</td><td>SWEPT</td><td colspan="2">FLUX AMPL.</td></tr>
<tr><td>B8</td><td>INCREASING</td><td>DECREASING</td><td colspan="2"></td></tr>
<tr><td>B7</td><td>20 mV</td><td>200 mV</td><td colspan="2">PULSE AMPL.</td></tr>
<tr><td>B6</td><td>20 kΩ</td><td>200 kΩ</td><td colspan="2">Rext-AC</td></tr>
<tr><td>B5</td><td>OFF</td><td>ON</td><td>R-DC Q4</td><td rowspan="3"><table>
<tr><td>Q 6</td><td>Q 5</td><td>Q 4</td><td>R</td></tr>
<tr><td>L</td><td>L</td><td>L</td><td>10kΩ</td></tr>
<tr><td>L</td><td>L</td><td>H</td><td>100kΩ</td></tr>
<tr><td>L</td><td>H</td><td>L</td><td>1MΩ</td></tr>
<tr><td>L</td><td>H</td><td>H</td><td>10MΩ</td></tr>
<tr><td>H</td><td>L</td><td>L</td><td>100MΩ</td></tr>
<tr><td>H</td><td>L</td><td>H</td><td>1GΩ</td></tr>
<tr><td>H</td><td>H</td><td>L</td><td>10GΩ</td></tr>
<tr><td>H</td><td>H</td><td>H</td><td>???</td></tr>
</table></td></tr>
<tr><td>B4</td><td>OFF</td><td>ON</td><td>R-DC Q5</td></tr>
<tr><td>B3</td><td>OFF</td><td>ON</td><td>R-DC Q6</td></tr>
<tr><td>B2</td><td>(CONT)</td><td>(STEP)</td><td colspan="2"></td></tr>
<tr><td>B1</td><td>YES</td><td>NO</td><td colspan="2">AC NOISE</td></tr>
<tr><td>B0</td><td>YES</td><td>NO</td><td colspan="2">PULSE NOISE</td></tr>
</table>

A B15...B31 bites are reserves. Default values: 0.

3.6.2 Value representation

Floating point numbers are represented in **IEEE-754** single precision (32 bit) format. This format allows the floating-point routines to take advantage of the processor architecture and reduce the amount of overhead required in the calculations. The representation is shown below:

Format	Exponent	Mantissa 0	Mantissa 1	Mantissa 2
IEEE-754	**s**xxx xxxx	**y**xxx xxxx	xxxx xxxx	xxxx xxxx

where
s is the sign bit,
y is the lsb of the exponent
x placeholder for the mantissa and exponent bits.

It needs to be mentioned that both numbers are organised in “big endian” order. Therefore the representation shows from the left hand side to the right the starting with the highest value and the lowest byte takes place on the right-wring.
The following calculator hyperlink helps converting decimal number to **IEEE-754** single precision (32 bit) format

http://babbage.cs.qc.edu/IEEE-754/Decimal.html

An example is to be found in Appendix 1.
It can be read that the 6.32E-05 decimal number is equivalent to 38848A3E hex in 32 bits IEEE 754 format.

3.6.3 Commands Issued by the PC and Simulators Reaction to them.

These are basically single-character commands without any checksum or control character companions. The verification of the commands correct interpretation is the operators observation of the expected reaction on the screen. (The main cause of this approach was originally the wish of shortening message traffic as much as possible).

The commands:

’S’ Start emitting simulated outputs

’P’ Stop

’r’ Send actual STATUS, PFREQU, ACURR, DCURR and FLUX values to PC in a single line, ending with an ’*’.

’W’ write parameter from the mail-box to its place in parameter table

’d’ dump parameters
Dumps parameter table, maintained in Simulator. This table contains all parameters defined in document (see Table1) dealing with FP-communication. The table entries -which are 4-byte hexadecimal numbers, separated by space and CR/LF characters- end with a ’$’ symbol.

To maintain the ’single-character command’ feature, later we adopted a mechanism by which one can transfer binary bytes to the Simulator by using the special ’L’ command. This one notes the FW in the simulator, that the next command will be a binary byte (instead of an ASCII character). This way sending e.g. a status-word (a two-byte value) looks like that:

’M’ ’L’ adbyte1 ’L’ adbyte2 ’V’ ’L’valbyte1 ’L’ valbyte2 ’L’ valbyte3 ’L’ valbyte4.

Where

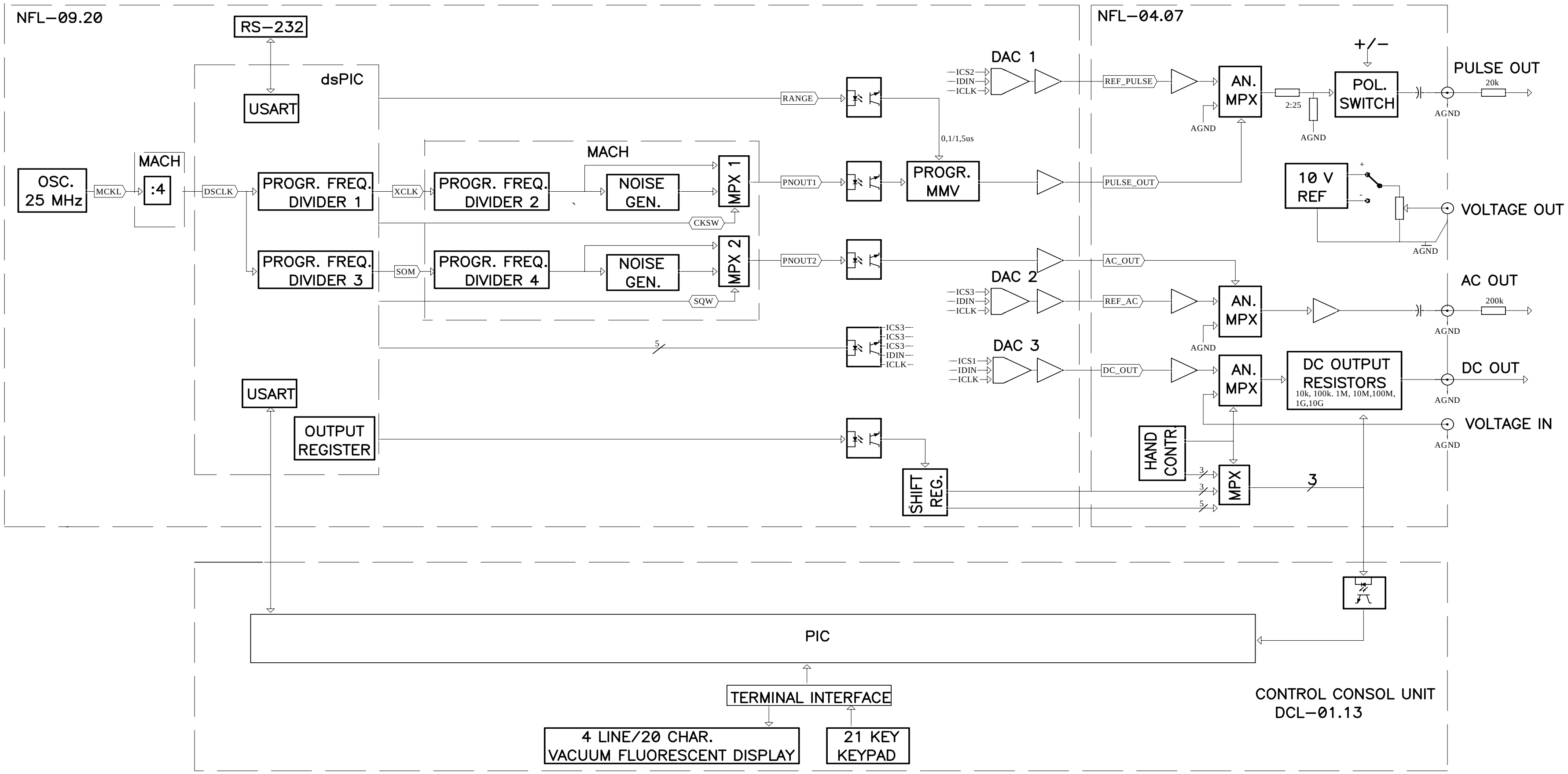
’M’ and **’V’** pointer-setting commands,
adbytex (2 bytes long) the binary address bytes to be transferred into the parameter-table.
valbytey (bytes long). the binary value bytes to be transferred into the parameter-table.

3.6.4 Programming with the Single-Character Commands

By using the handful of simple commands described in 3.6.3 one can easily write a shell-program to control the simulator via RS 232 connector. The only precondition to this understands the working of the Simulator on the ground of the main parameters, with special care of the Status Word.

After this one has to send

- the application‘s controlling parameters
  (as many **M**LL**V**LLLL-sequences each is followed by **W** as are parameters to change)
- Review them in a text-box
  (send ‘**d**’ command)
- Finally start (‘**S**’).



Block diagram

4 Instructions for use

The operation of the simulator has the following steps:

1. In order to select the suitable parameters the characteristics of the simulated nuclear reactor, detector and signal processor needs to be collected. What needs to be specified are as follows:
   a. K4 [%/ny]: the relationship between neutron flux measured on the position of detector and the nuclear power supplier performance
   b. From the simulated detector's catalogue data originated parameters which can be seen in the table below

Measurement mode	Parameter		
	Name	Marking [Unit of measure]	Setting range
Impulse	Sensitivity The upper corner point of linear range Signal amplitude Signal width	K1 [pps/nv] PFLUX1 [nv] PULSE AMPL [mV] PULSE WIDTH [µs]	1.0E-01 to 1.0E+01 1.0E+03…1.0E+07 20, 200 0.1, 1.5
AC	Sensitivity The lower corner point of linear range	K2 [µA/√nv] ˟ AFLUX0 [nv]	1.0E-06…1.0E-03 1.0E+02…1.0E+05
DC	Sensitivity The lower corner point of linear range The upper corner point of linear range	K3 [µA/nv] ˟ DFLUX0 [nv] DFLUX1 [nv]	1.0E-11…1.0E-05 1.0E+02…1.0E+11 1.0E+02…1.0E+11

˟ The value of K2 scaling factor can be calculated from the following formula

$K2=\sqrt{(S.B)}$
Where

K2	Scaling factor of AC signal	[µA/√nv]
S	Neutron sensitivity of detector in fluctuating mode	[A^2 /Hz*nv]
B	Bandwidth of processing part	[Hz]

   c. Bandwidth of the band-pass filters B [Hz] using in the AC (Campbell) channel. This parameter is needed to calculate K2 parameter

2. The device can be switched on with the POWER ON switch from the front end.
3. Connecting the resistance probes to the PULSE and the AC connectors.
   As a start
   - To the PULSE connector a 20 kΏ probe-
   - To the AC connector a 200 kΩ probe needs to be connected.
4. Inserting the parameters acquainted (above in the point number 1) can be execute in two ways:
   - Through the device' front end control and display facilities.
   - Through a RS 232 serial port
5. Inserting the parameters that needs to simulate the nuclear reactor (listed on the display, p. 1).

6. Setting the AC signals' nominal frequency (ACFREQU). Most of the time it needs to be set as 50kHz.
7. The PULSE and the AC output's noise property settings.

PULSE NOISE	The PULSE output signal frequency Noisy(Y)/ Constant (N)
AC NOISE	The AC output signal amplitude. Noisy(Y)/ Constant (N)

8. The DC DESISTANCE CONTROL switch needs to be set to AUT.
9. The simulation can be start with pressing the START button

5 User manual for the front panel control and display facilities

For the device' human and electronic interaction a 21button keyboard and a VF display (4 row, 20 characters/row) are responsible.
The keyboards' keys are arranged in the following way:

0…9	The setting of the value of the marked parameter
+/-	The setting of the marked parameter exponent polarity
↑ , ↓,←,→	The adjustable parameter marker cursor moving key
SET	The parameter activator that was marked with the cursor
ESCAPE	Exiting the parameter marked with the cursor without amending it.
ENTER	The execution of the amendment of the parameter marked by the cursor
START	Starting the simulator
STOP	Exiting the simulator
PAGE UP	The key that is responsible for changing the 4 row view (page) on the display

Using the PAGE UP key the following parameters can be selected which can be viewed on the pages:

1. page Parameters to set the neutron flux in time order

F	L	U	X			:			X	.	X	X	E	X	X	X		n	v
F	L	U	X	0		:			X	.	X	X	E	X	X	X		n	v
F	L	U	X	1		:			X	.	X	X	E	X	X	X		n	v
T	.	P	E	R		:			X	.	X	X	E	X	X	X			s

FLUX	The momentary value of the simulated neutron flux	Calculated parameter
FLUX0	The lower final value of the neutron flux	Parameter that needs to be set
FLUX1	The higher final value of the neutron flux	Parameter that needs to be set
T.PER	Exponential variable neutron flux time constraint after the START command selected	Parameter that needs to be set

The momentary signals that can be seen on the simulators PULSE, AC and DC outputs depend on the simulated neutron flux current value. Before giving the START command the neutron flux either provides the previous cycle FLUXO/FLUXI final value or it stagnates on the value at the moment on the STOP command given. After giving the START command the, neutron flux timing can be set with the FLUX0, FLUX1, T.PER and FLUX AMPL parameters according to the following: (See Fig. 6.)

- If the FLUX AMPL=CONST in this case the neutron flux is stagnated on the FLUXO parameters level.
- If the FLUX AMPL=INCR, the neutron flux effects the new cycle in a way, that from the value that was standardised in the previous cycle with T PER time constant increasing exponentially. If the STOP command is launched before the FLUX1 value is reached the neutron flux is stabilised at the moment when the command is given. In the case when STOP command is not launched the neutron flux is increasing until it reaches FLUX1 value and after it remains stable.
- If the FLUX AMPL=DECR, the neutron flux effects the new cycle in a way, that from the value that was standardised in the previous cycle with T PER time constant decreasing exponentially. If the STOP command is launched before the FLUX0 value is reached the neutron flux is stabilised at the moment when the command is given. In the case when STOP command is not launched the neutron flux is decreasing until it reaches FLUX0 value and after it remains stable.

<u>2. page.</u> Displaying the momentary power and current and setting theDC characteristic corner value

Display

P	W	R				:	X	.	X	X	E	X	X	X			%
D	C	U	R	R		:	X	.	X	X	E	X	X	X		µ	A
D	F	L	U	X	0	:	X	.	X	X	E	X	X	X		n	v
D	F	L	U	X	1	:	X	.	X	X	E	X	X	X		n	v

PWR	The momentary value of the simulated power PWR=K4*FLUX	Calculated parameter
DCURR	The simulated current momentary value DCURR= K3*FLUX	Calculated parameter
DFLUX0	The DC characteristics' bottom corner point (see on Fig. 4.)	Parameters that needs to be set
DFLUX1	The DC characteristics top corner point (see on Fig. 4.)	Parameters that needs to be set

3. page Displaying the momentary impulse frequency and the AC current, setting the impulse and AC characteristics corner points

Display

F	R	E	Q	U			:		X	.	X	X	E	X	X	X	p	p	s
P	F	L	U	X	1		:		X	.	X	X	E	X	X	X		n	v
A	C	U	R	R			:		X	.	X	X	E	X	X	X		μ	A
A	F	L	U	X	0		:		X	.	X	X	E	X	X	X		n	v

FREQU	The simulated impulse frequency momentary value FREQU=K1*FLUX	Calculated parameter
PFLUX1	The PULSE characteristics top corner point (see on Fig. 2.)	Parameters that needs to be set
ACURR	The simulated AC signals' amplitudes' momentary value AFLUX =K2*FLUX	Calculated parameter
AFLUX0	The AC characteristics top corner point (see on Fig. 3.)	Parameters that needs to be set to be set

4. page The detector and the nuclear reactor's sensitivity parameters

Display

K	1		:		X	.	X	X	E	X	X	X		p	p	s	/	n	v
K	2		:		X	.	X	X	E	X	X	X		μ	A	/	√	n	v
K	3		:		X	.	X	X	E	X	X	X			μ	A	/	n	v
K	4		:		X	.	X	X	E	X	X	X				%	/	n	v

K1	The detectors' sensitivity in pulse work of operation	Parameters that needs to be set
K2	The detectors' sensitivity in AC work of operation	Parameters that needs to be set
K3	The detectors' sensitivity in DC work of operation	Parameters that needs to be set
K4	Power factor	Parameters that needs to be set

5. page. Unclassified parameters

Display

A	C	F	R	E	Q	U	:		X	.	X	X	E	X	X	X		H	z
R	i	n	t	-	D	C	:		X	.	X	X	E	X	X	X		Ω	
R	e	x	t	-	A	C	:				2	0	0					k	Ω
F	L	U	X			A	M	P	L	.		:		c	o	n	s	t	.

ACFREQU	The AC outputs' signal nominal frequency	Parameters that needs to be set
Rint-DC	Resistance connected to the DC output (internal)	Displayed parameter
Rext-AC	Resistance connected to the AC output (external)	Parameters that needs to be set
FLUX AMPL*	Setting of the neutron flux' timing parameters	Parameters that needs to be set

- *A FLUX AMPL parameters that can be set
- CONST START after on the neutron flux FLUXO remains the same
- INCR START after the neutron flux is increasing from the previous cycles' level exponentially until the STOP command but the maximum is the FLUX1 level
- DECR START after the neutron flux is decreasing from the previous cycles' level exponentially until the STOP command but the maximum is the FLUX0evel

6. page The PULSE and the AC output signal parameters

Display

P	U	L	S	E		A	M	P	L	.		:		X	X	X		m	V
P	U	L	S	E		W	I	D	T	H		:		X	.	X		μ	s
P	U	L	S	E		N	O	I	S	E		:		y	e	s			
A	C					N	O	I	S	E		:		y	e	s			

PULSE AMPL	The PULSE output signal amplitude 20 mV/200mV	Parameters that needs to be set
PULSE WIDTH	The PULSE output signal width 100 ns/2 µs	Parameters that needs to be set
PULSE NOISE	The PULSE signal output frequency Noisy(Y)/Constant (N)	Parameters that needs to be set
AC NOISE	The AC output signal amplitude Noisy(Y)/ Constant(N)	Parameters that needs to be set

6 Maintenance of the instrument

Inside the device, heat-removal has to be provided, hence the heat sinks of the modules, the ferrite elements and their surroundings have to be cleaned annually (in a dusty environment more often, if necessary). While cleaning, check visually the modules and the connecting cables. Clean the display and the device controls with a wet cloth rubbing carefully. The instrument does not require other maintenance. The free distance for the instrument top and bottom is minimum 1U (1,75 inch).
Only a qualified person can do these works. The modules can be removed from the device only one minute after switch-off from front side.
If necessary, but at least annually the main parameters of the instrument should be checked as it is described in attached testing reports. In case of malfunction is expected first contact Regtron Ltd describing the phenomenon. Our experts take advices the way of repair. In worst case after removing of module(s) customer have to send it back to Regtron site to repair it.
The life protection earth has to be checked in prescribed periods, but at least annually. The same applies to the instrument and the whole of the measuring assembly.

7 TECHNICAL DATA

Signals Generated:
Different outputs operate simultaneously. Output levels are set always by the (preset) nv values.

7.1 Neutron Flux Simulation

Neutron flux range	1.00E+00 to 1.00E+11 nv	
Time function	Constant or exponential	
Exponential signal parameters		
Starting level FLUX0	1.00E+00 to FLUX1 nv	settable
Stopping level FLUX1	FLUX0 to 1.00E+11 nv	settable
Time constant T.PER *	1.00E+01 to 1.00E+02 s	settable
Neutron flux to power conversion		
Scaling factor PW (K4)	1.00E-09 to 1.00E-07 %/nv	settable

*Time constant for AC output always twice as much as for Pulse and DC one.

The OPERATING MODES and other programmable parameters (e.g. output pulse amplitude, pulse frequency) can be selected by program. The following table shows in summarized form all the possible operating modes connected with the necessary parameter settings.

Operation mode	PULSE OUT	AC OUT	DC OUT
0	Fixed frequency, Fixed amplitude.	Fixed frequency, Adjustable amplitude	Adjustable DC value
1	Fixed average frequency, Fixed amplitude	Fixed average frequency, Adjustable amplitude	Adjustable DC value
2	Exponentially swept frequency, Fixed amplitude.	Exponentially swept frequency, Amplitude follows the root-square rule.	Exponentially swept DC value
3	Exponentially swept average frequency Fixed amplitude	Exponentially swept average frequency, Amplitude follows the root-square rule.	Exponentially swept DC value

7.2 Pulse Output

Scaling factor K1	1.00E-01 to 1.00E+01 pps/nv	settable
Frequency		
Range	1 pps to 2 Mpps	
Resolution	Max 1.00E-04 pps (at 1 pps) Max 1.00E+02 pps (at 2 Mpps)	
Time distribution	Periodic, stochastic	
Higher corner point PFLUX1	1.00E+03 to 1.00E+07 nv	settable
Pulse		
Width	0.1 µs / 1.5 µs pulses	selectable
Amplitude	20mV/200 mV (at 20 kΩ load)	selectable
Polarity	+ or - (selectable)	
Stability (8 hours)	Width: ± 0. 5 % Amplitude: ± 1 %	
Connector type	BNC	

7.3 DC Output

Scaling factor K3	1.00E-11 to 1.00E-05 µA/nv
Signal type	Direct current
Amplitude range	10 mV- 10 V
Amplitude resolution	16 bits
Serial resistance	10 kΩ, 100 kΩ, 1 MΩ, 10 MΩ, 100 MΩ, 1 GΩ, 10 GΩ (selectable)
Lower corner point DFLUX0	1.00E+02 to 1.00E+11 nv (settable)
Higher corner point DFLUX1	1.00E+02 to 1.00E+11 nv (settable)
Integral linearity	< ± 0.1 % of Full Scale
Stability (8 hours)	± 0.25 %
Connector type	BNC

7.4 AC Output

Scaling factor K2	1.00E-06 to 1.00E-03 µA/√nv settable
Signal type	Pulses with settable amplitude.
Amplitude range	10mV to 10V
Amplitude resolution	16 bits
Nominal frequency AFREQU	1.00E+04 to 5.00E+04 pps settable Stochastic or periodic
Serial resistance	200 kΩ (external)
Lower corner point AFLUX0	1.00E+02 to 1.00E+05 nv settable
Integral linearity	< ± 0.1 % of Full Scale
Stability (8 hours)	± 0.25 % (amplitude)
Connector type	BNC

The value of K2 scaling factor can be calculated from the following formula
K2=√(S.B)
Where

K2	Scaling factor of AC signal	[µA/√nv]
S	Neutron sensitivity of detector in fluctuating mode	[A^2 /Hz*nv]
B	Bandwidth of processing part	[Hz]

In the following table K2 is calculated-as examples- for three different detectors and with tree different bandwidths.

Detector type	Neutron sensitivity [A^2 /Hz*nv]	Bandwidth [Hz] 5.00E+04	1.00E+05	2.00E+05
		K2 [µA/√nv]		
CFUG 08	1.60E-25	8.94E-05	1.26E-04	1.79E-04
CFUL 08	4.00E-26	4.47E-05	6.32E-05	8.94E-05
CFUM 18	4.00E-27	1.41E-05	2.00E-05	2.83E-05

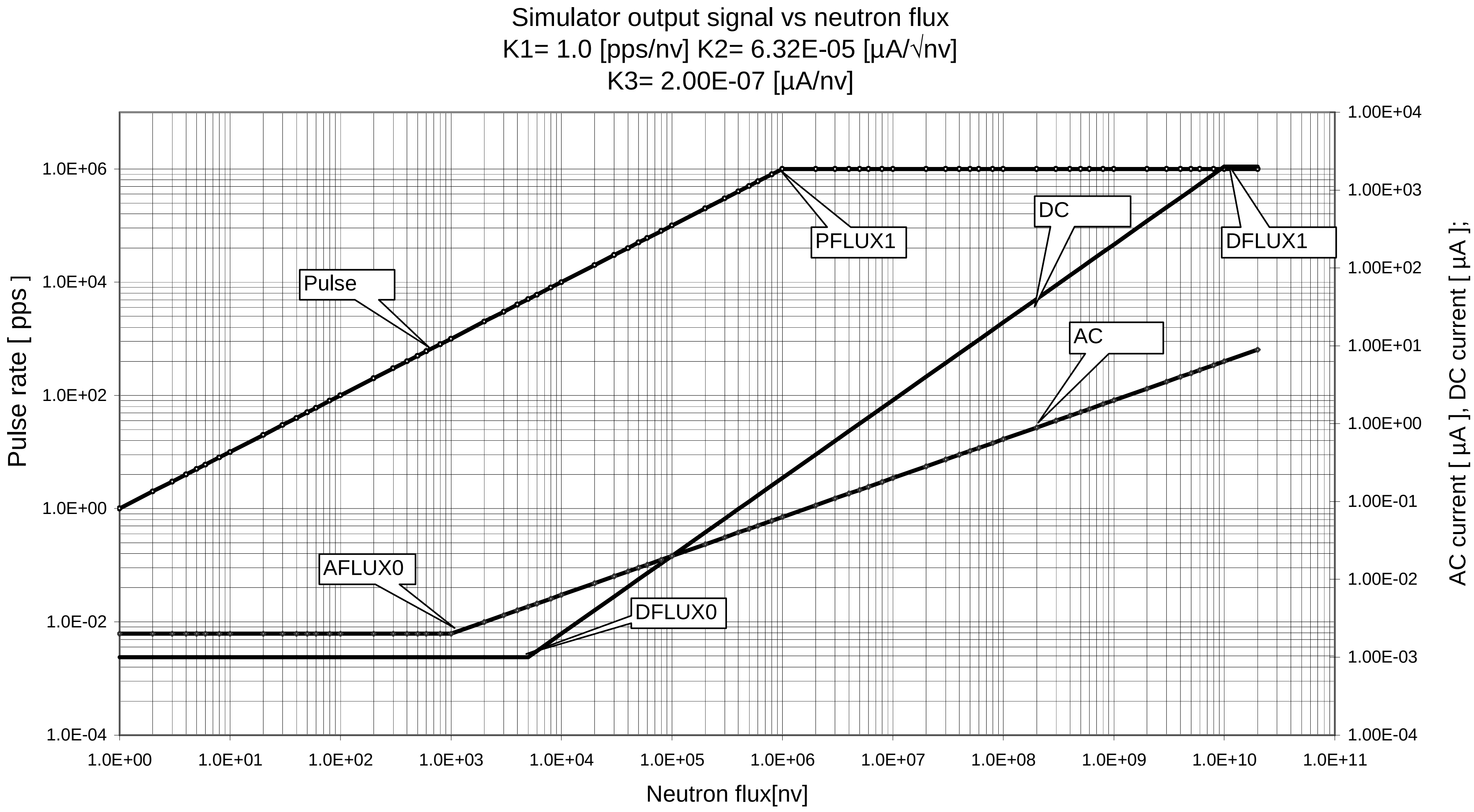


Fig. 1 Simulator characteristics

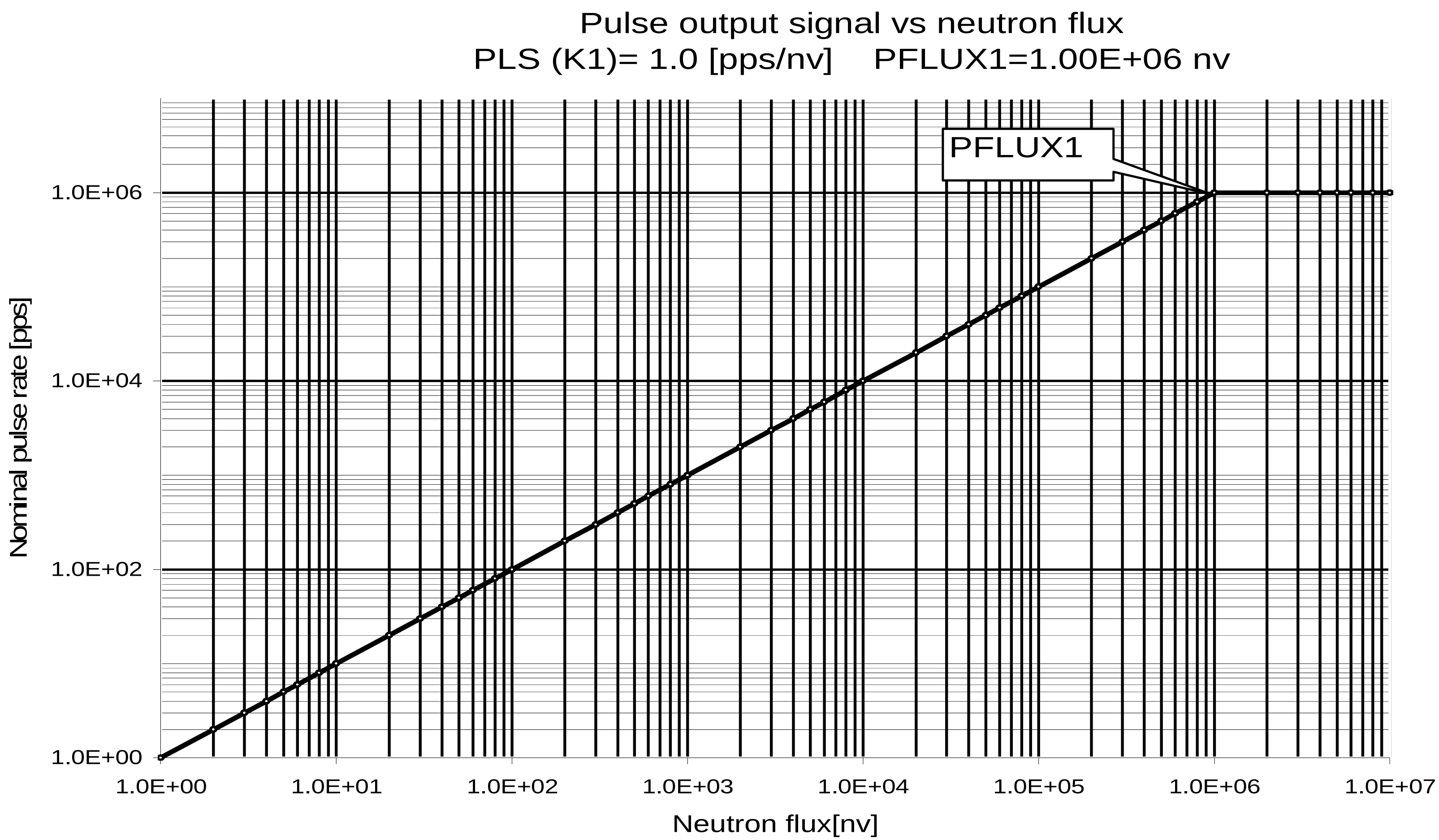


Fig. 2 Pulse output signal vs neutron flux characteristics.

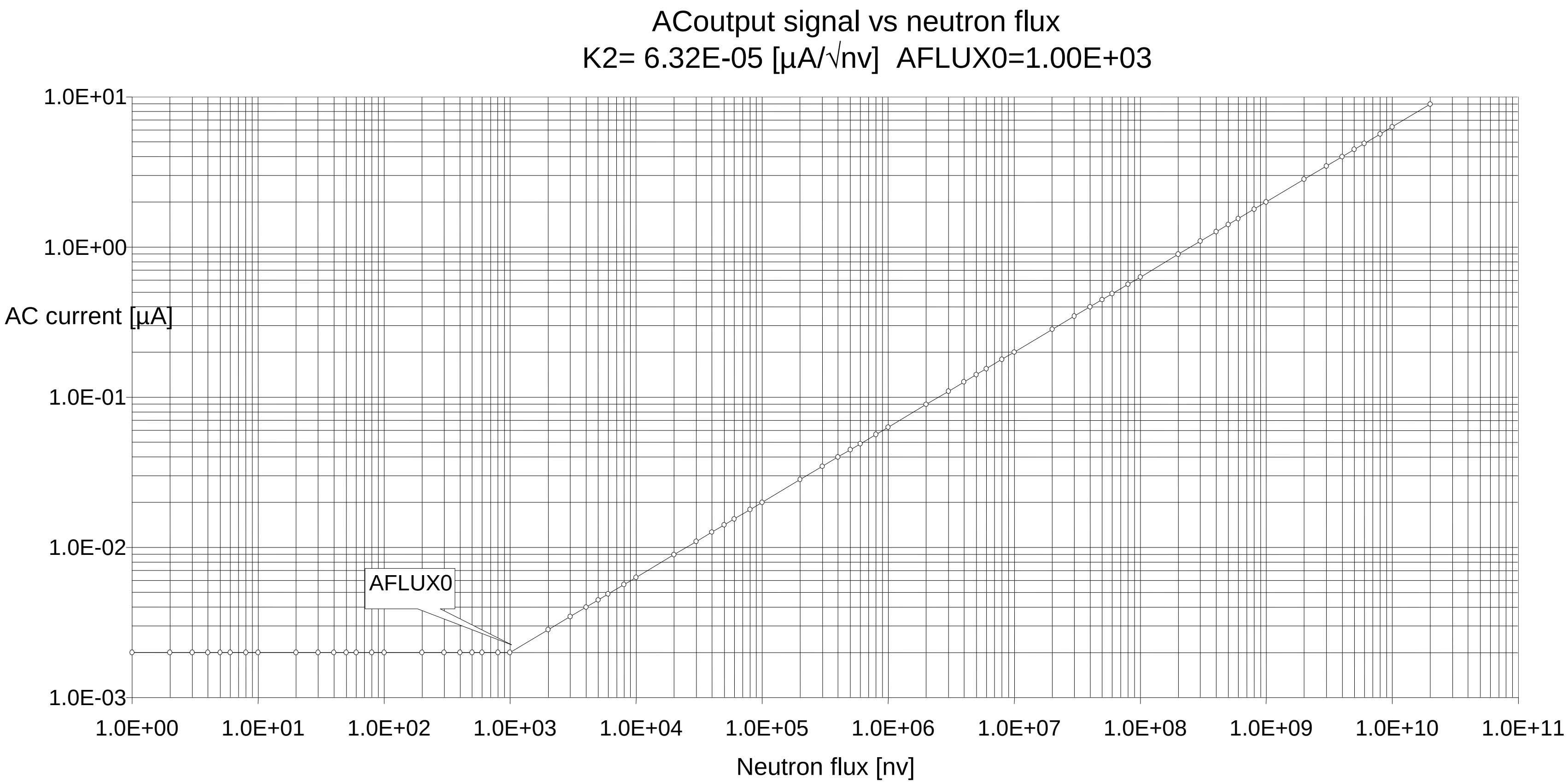


Fig. 3 AC output signal vs neutron flux characteristics.

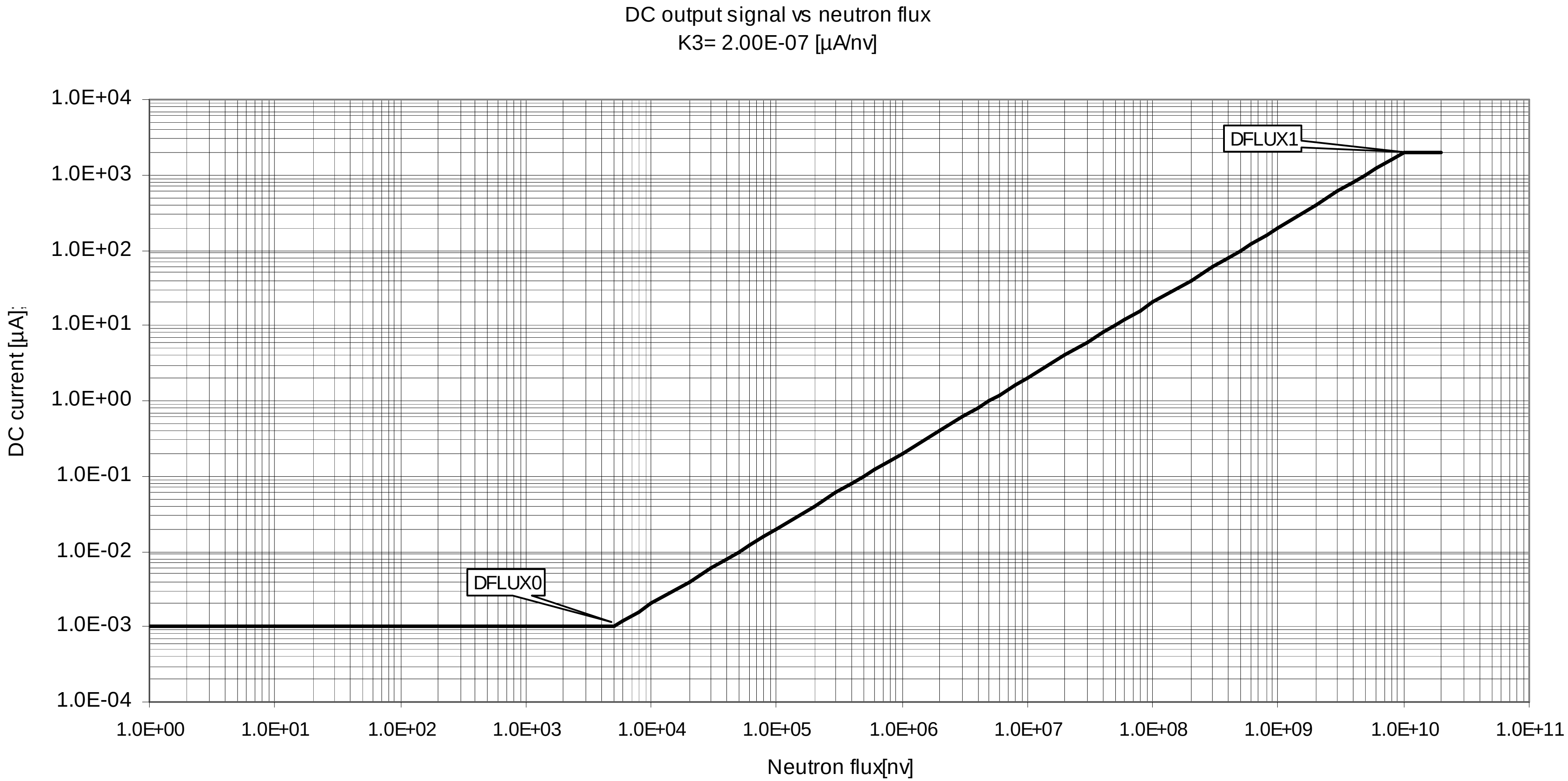


Fig. 4 DC output signal vs neutron flux characteristics.

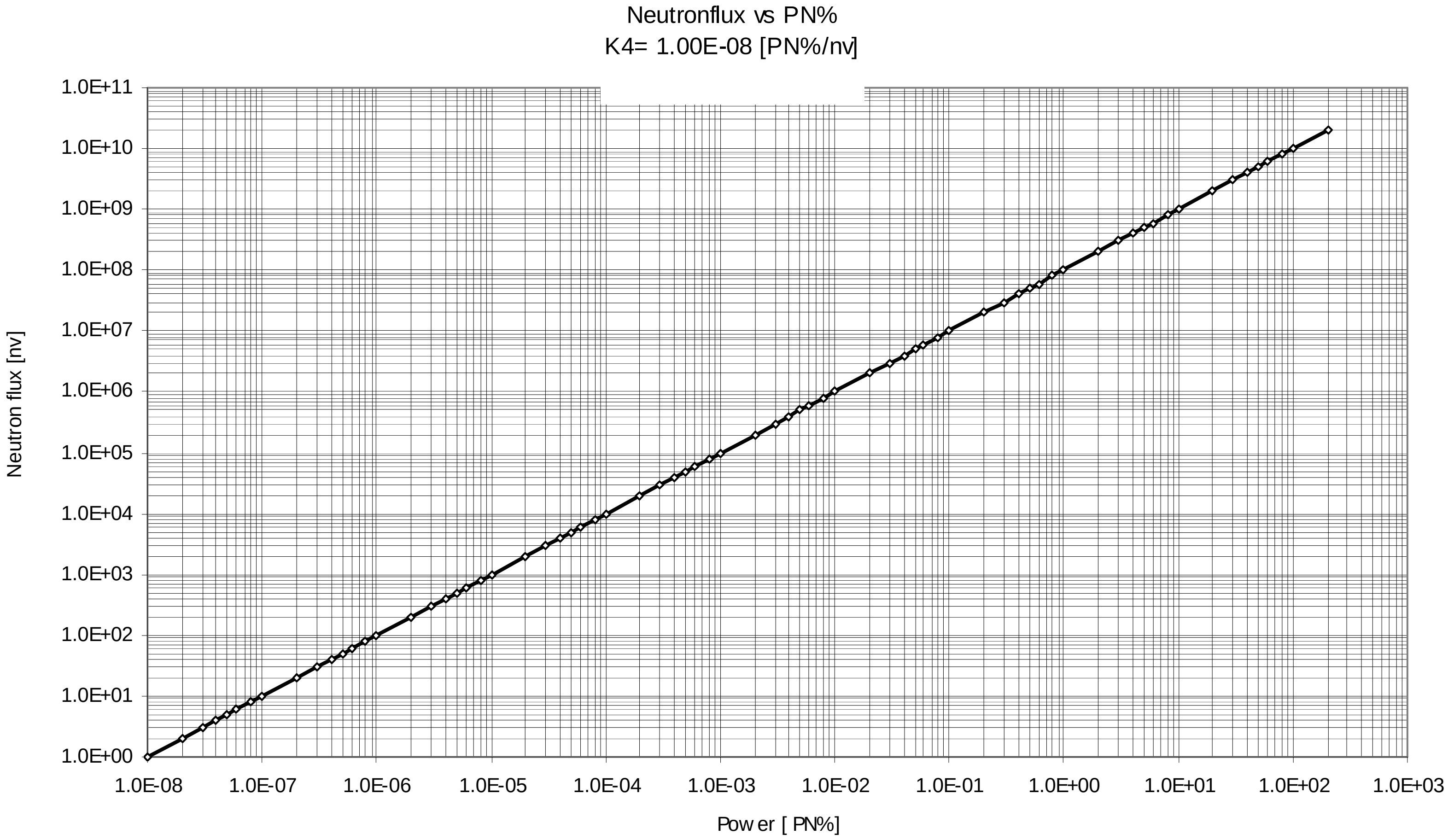


Fig. 5 Power level vs neutron flux characteistics.

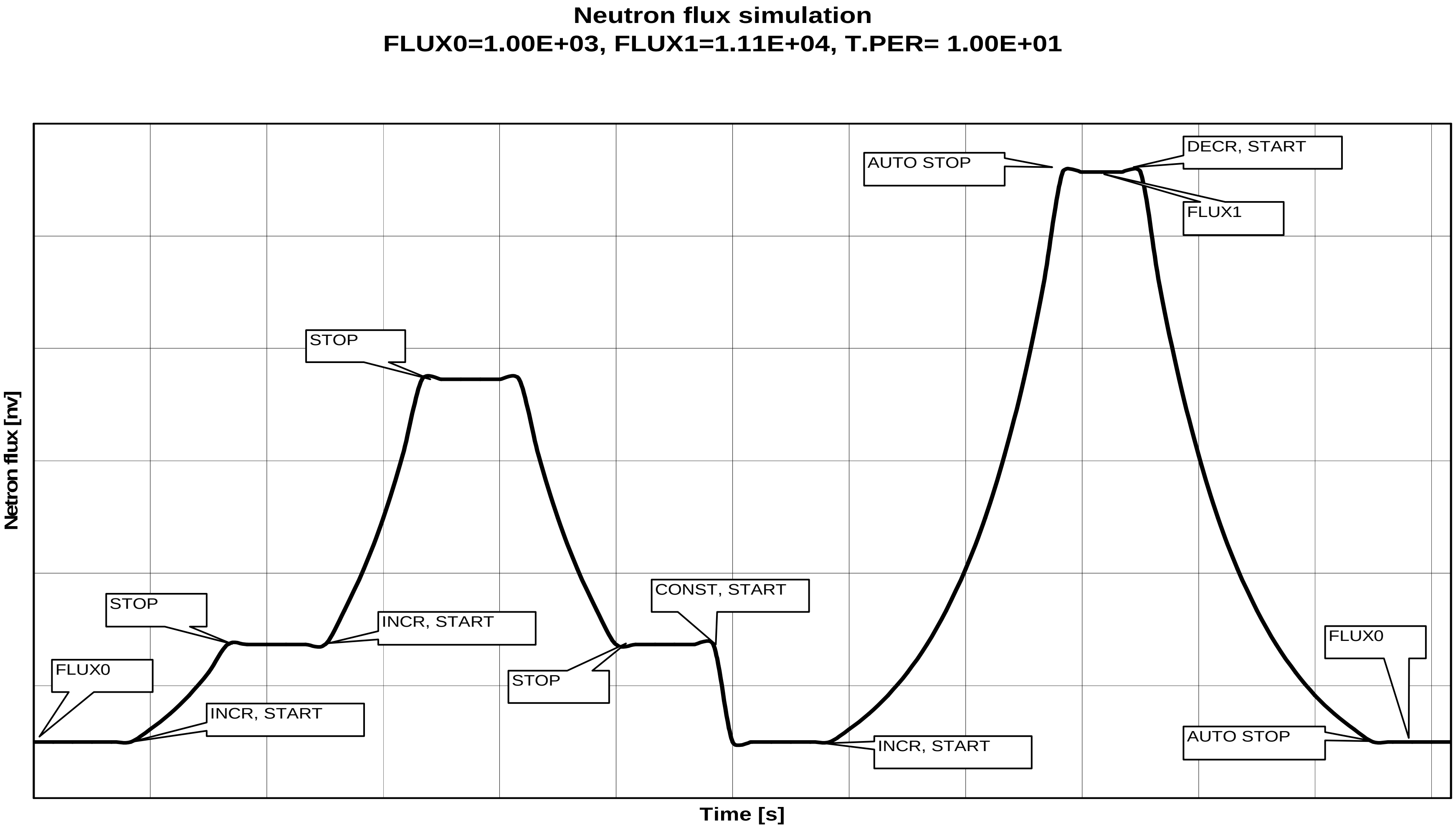


Fig. 6 Neutron flux characteristics.

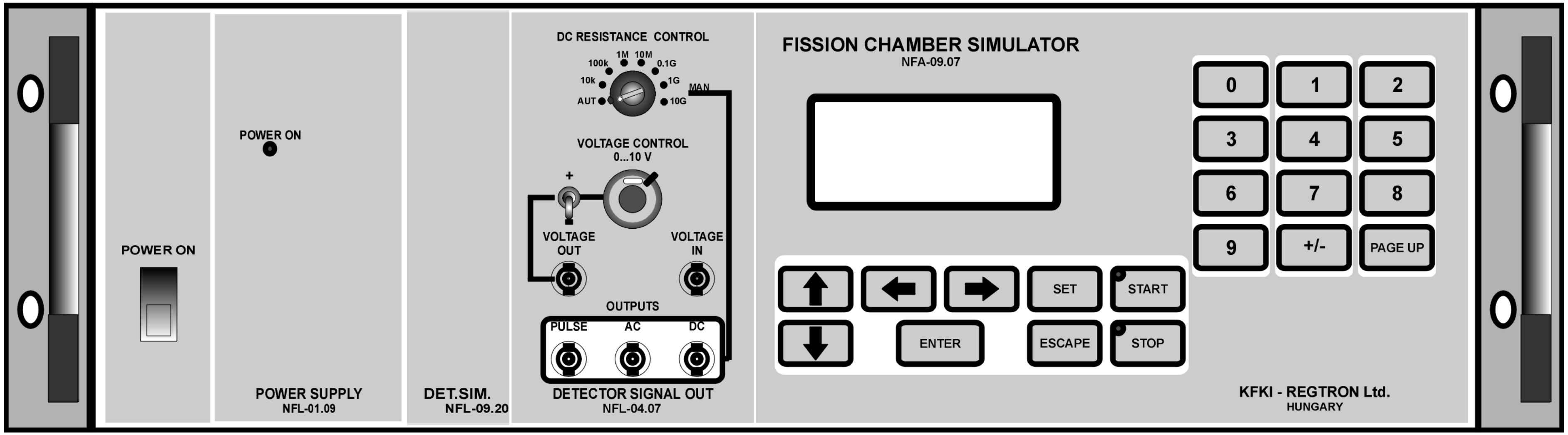


Fig.7 Front panel view.