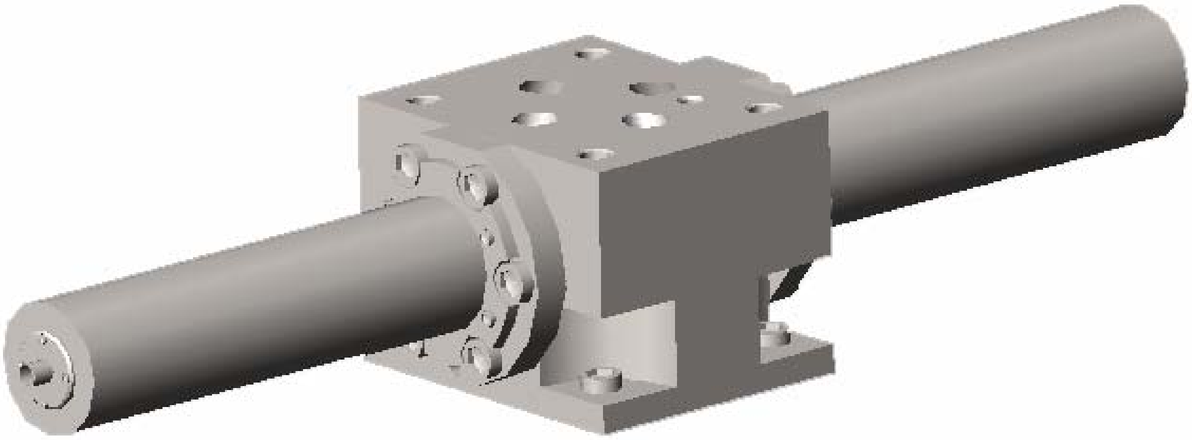
Frequency response cylinder

This frequency response piston is laid out to be installed between the servovalve to be tested and the manifold of the test bench ValveExpert (see catalogue ValveExpert). The position and velocity transducers will be connected to the test-stand with a single connector mounted on the piston.

The port pattern of this cylinder corresponds to the norm: ISO 10372-06-05-0-92,
and therefore corresponds to the port pattern of series 72 servovalves of Moog, series 890 of Star-Hydraulic or series 4550 of Ultra.



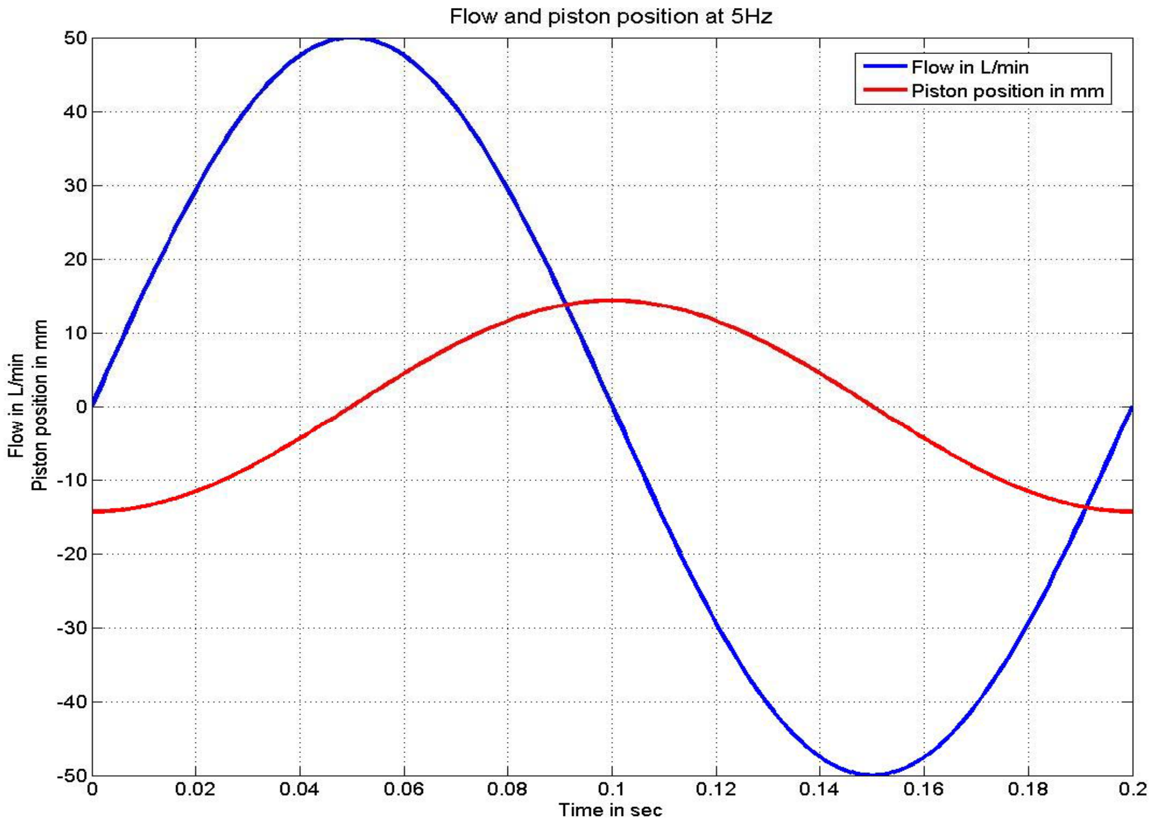
Frequency response piston
Specification

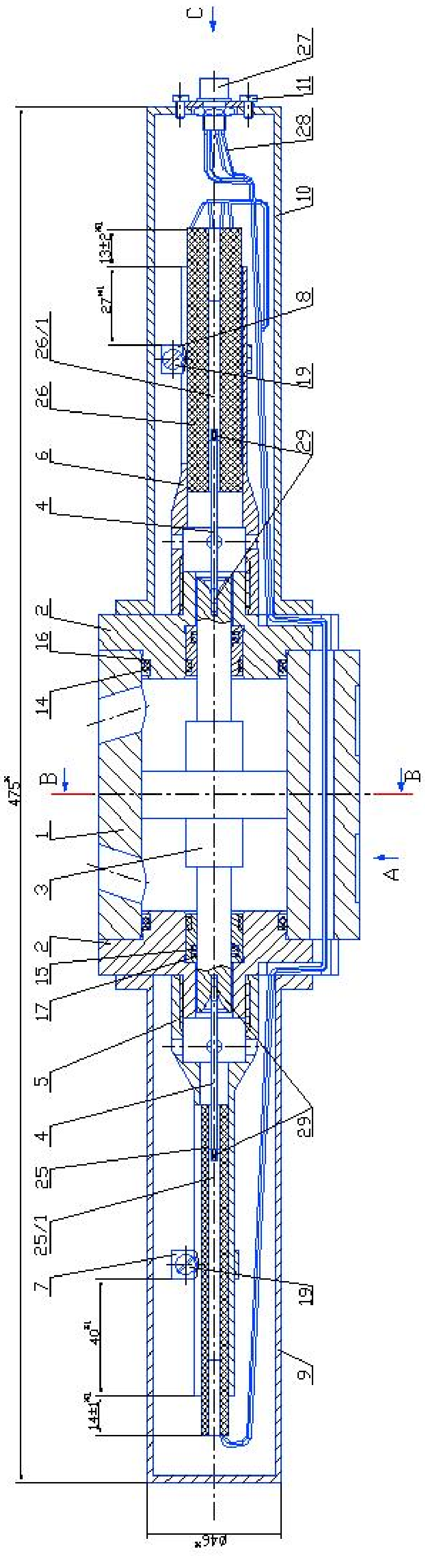
Piston
Piston diameter: 50 mm
Rod diameter: 12 mm
Effective piston area: 19 cm^2
Total effective stroke: 30 mm (± 15 mm)
The piston seals are O-rings. The piston is not frictionless. However with the larger piston area together with the high pressure gain of the servovalves, this friction is negligible.

Position transducer
Type: DC-DT LVDT
Supply voltage: 6 to 30 Volt DC
Output at full extension: 14 Volt with 24 Volt supply
Non linearity: ± 0,5 % of full scale

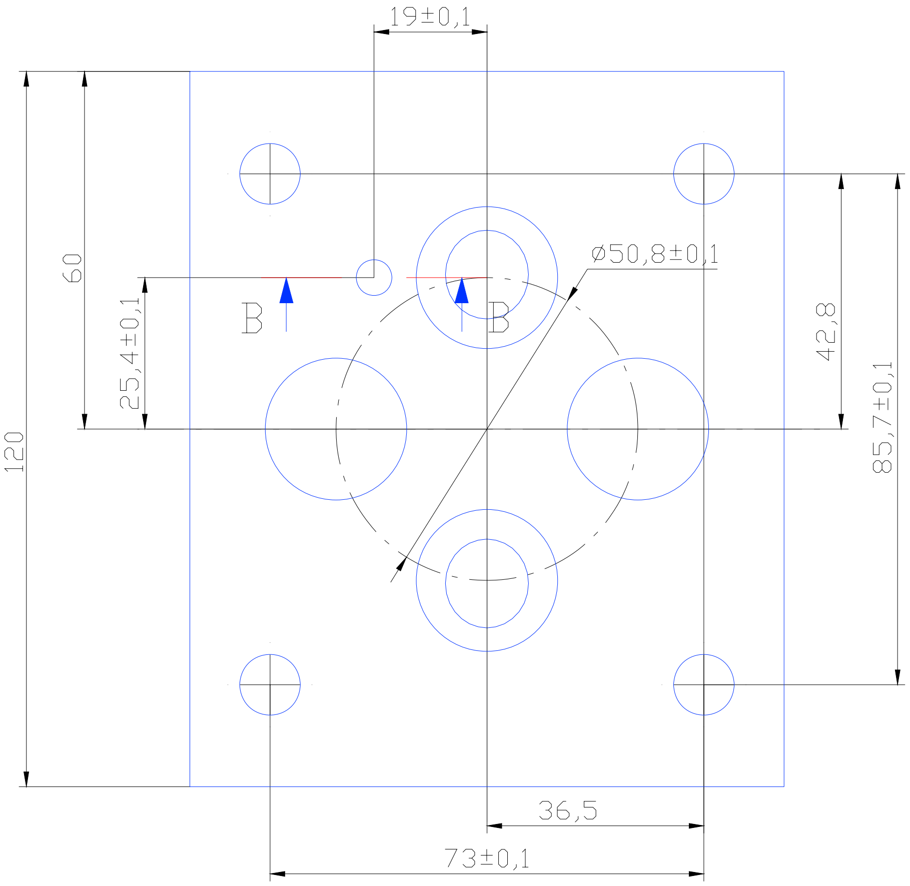
Velocity transducer:
Electrical impedance: 2500 Ohms
0,065 Henries
Output sensitivity: 4 mV/mm/sec
Frequency response: 1500 Hz (when load min. 250 k Ohms)

This diagram shows the maximum flow possible (due to the restricted stroke of the piston) when the reference frequency is 5 Hz. When choosing a reference frequency of 10 Hz, this flow is evidently two times larger or about 100 L/min.

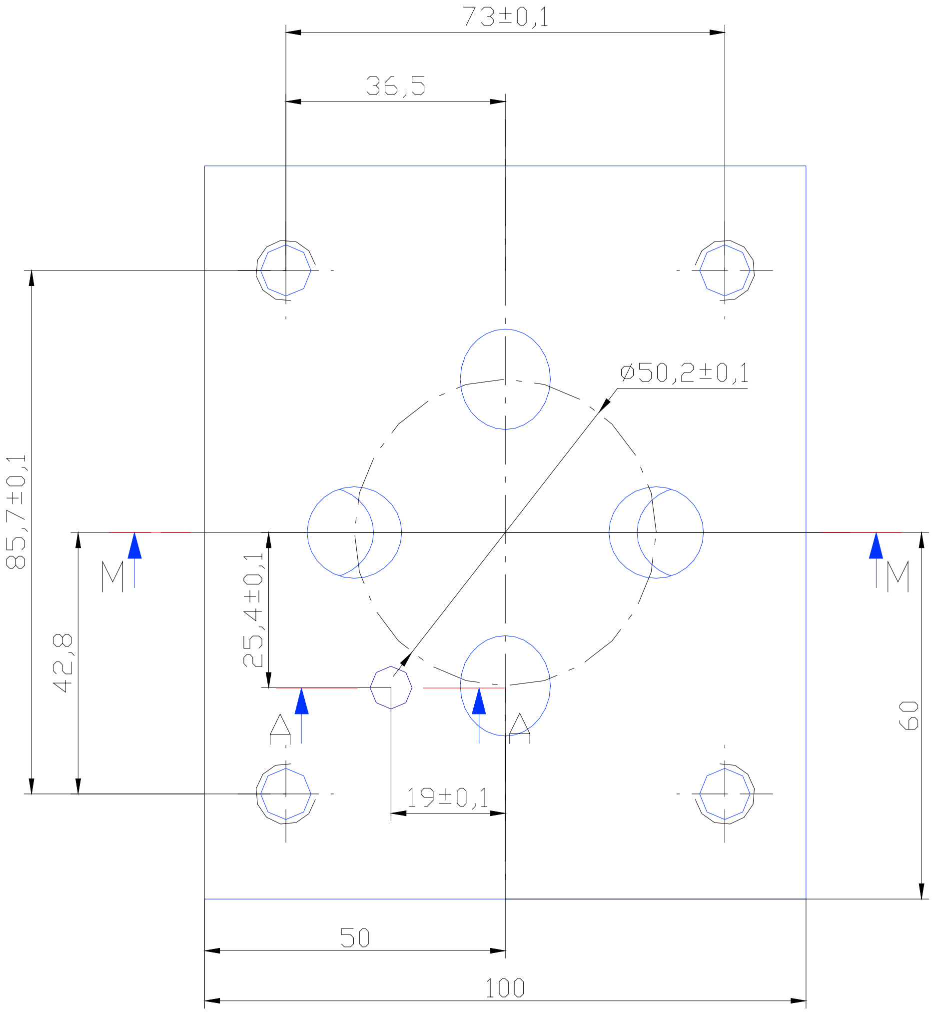



C
27
11
28
10
13±2*1
27*1
8
26/1
19
26
29
6
4
2
16
14
475*
B
B
1
3
A
2
15
17
5
4
29
25
25/1
7
19
40*1
14±1*1
9
Ø46*

Lower side of frequency cylinder
Dimensions of port pattern:

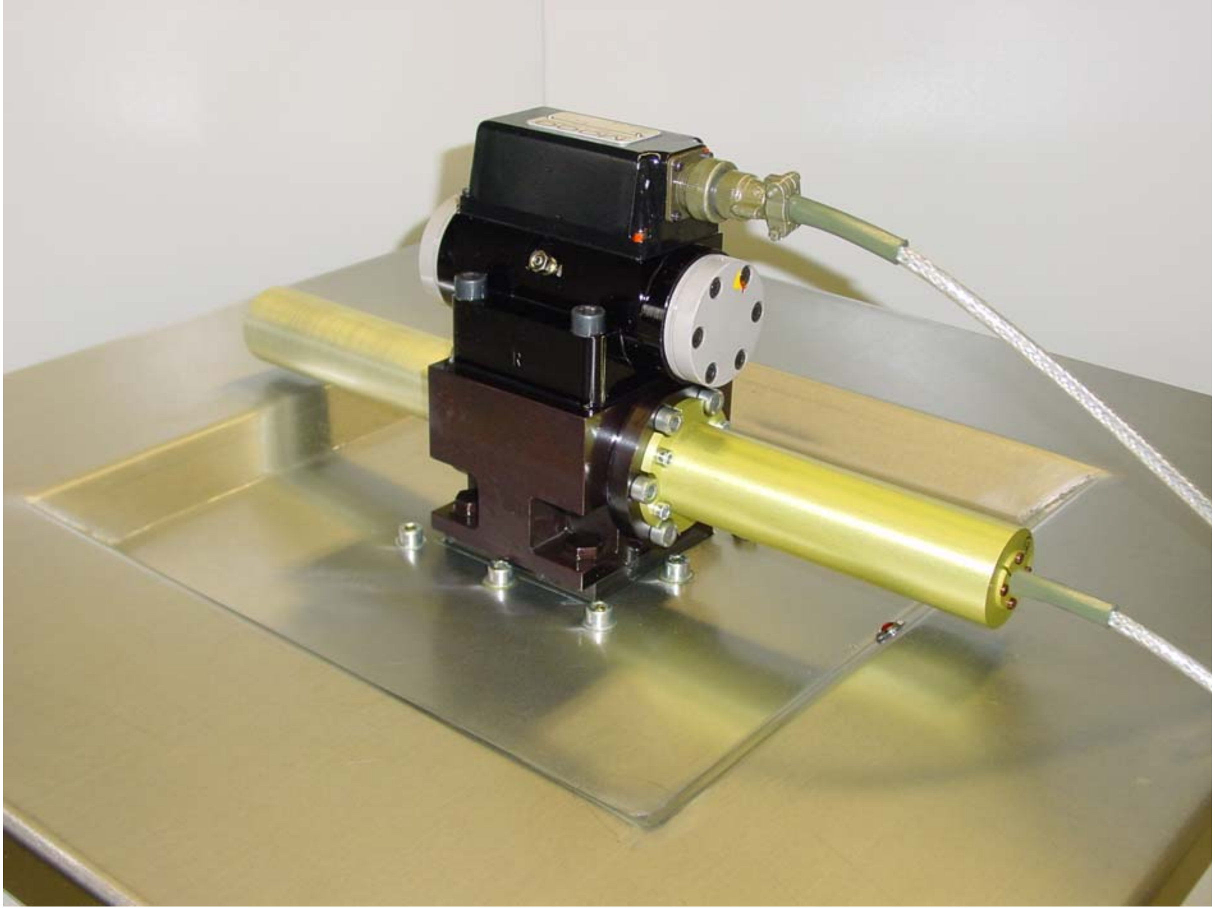


Upper side of frequency response cylinder
Port pattern dimensions



Evaluation of the dynamic performances (soft-ware)

To evaluate the dynamic performances of a mechanical feedback servovalve, a frequency response piston has to be mounted below the valve under test (option). The piston is equipped with a position transducer which allows controlling the piston in its mid-position and a velocity transducer for the flow measurement.
For electric feedback valves such a frequency response piston is not necessary as the signal of the spool position can be used for the dynamic evaluation.



The dynamic performances of a servovalve may be described in approximation by linear differential equations (so called linear models). Therefore suppliers of servovalves usually indicate the natural frequency (phase lag at 90° and amplitude at this frequency) of the servovalve to describe the dynamic response. To define the amplitude-phase characteristic of the servovalve we shall search for the best linear system, which describes it. This is the conducting idea, which we use in our program to determine the dynamic performances of the servovalve. To determine the dynamics we use following equation with three parameters:

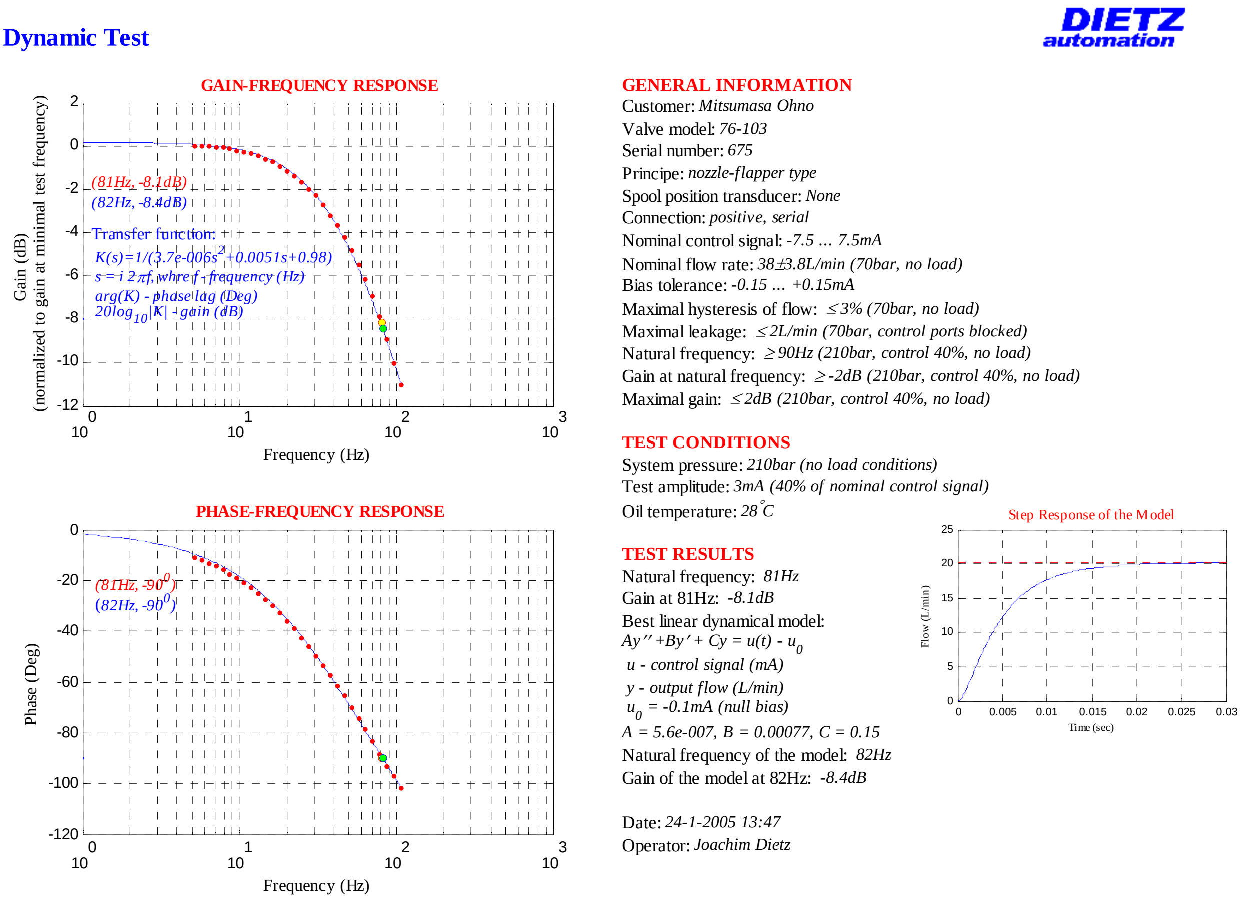
$$A\frac{\partial^3 y}{\partial t^3} + B\frac{\partial^2 y}{\partial t^2} + C\frac{\partial y}{\partial t} + Dy = u(t) - u_0$$

and following starting conditions

$$\left.\frac{\partial^2 y}{\partial t^2}\right|_{t=0} = \left.\frac{\partial y}{\partial t}\right|_{t=0} = \left.y\right|_{t=0} = 0$$

Where *u(t)* – is the input signal of the servovalve and y*(t)* – the output flow of the servovalve (u_0 is the bias signal). Under the assumption that the servovalve can be described with such an equation, we conduct the test with a defined function *u(t).* Then we become the output function y*(t)* and produce the recognition process to determine the parameters A, B and C. With the knowledge of the equation we determine the dynamic performances of the servovalve such as phase lag and amplitude.

The results of the dynamic tests are represented in a Bode diagram as it is usually done by the servovalve manufacturers. The red points on the diagram show the actual measured values. The blue line represents the evaluation of the differential equation which best represents the dynamics of this valve.



Dynamic Test

DIETZ
automation

GENERAL INFORMATION

Customer: *Mitsumasa Ohno*
Valve model: *76-103*
Serial number: *675*
Principe: *nozzle-flapper type*
Spool position transducer: *None*
Connection: *positive, serial*
Nominal control signal: *-7.5 … 7.5mA*
Nominal flow rate: *38±3.8L/min (70bar, no load)*
Bias tolerance: *-0.15 … +0.15mA*
Maximal hysteresis of flow: *≤3% (70bar, no load)*
Maximal leakage: *≤2L/min (70bar, control ports blocked)*
Natural frequency: *≥90Hz (210bar, control 40%, no load)*
Gain at natural frequency: *≥-2dB (210bar, control 40%, no load)*
Maximal gain: *≤2dB (210bar, control 40%, no load)*

TEST CONDITIONS

System pressure: *210bar (no load conditions)*
Test amplitude: *3mA (40% of nominal control signal)*
Oil temperature: $28^{\circ}C$

TEST RESULTS

Natural frequency: *81Hz*
Gain at 81Hz: *-8.1dB*
Best linear dynamical model:
$Ay'' + By' + Cy = u(t) - u_0$
u - control signal (mA)
y - output flow (L/min)
u_0 *= -0.1mA (null bias)*
A = 5.6e-007, B = 0.00077, C = 0.15
Natural frequency of the model: *82Hz*
Gain of the model at 82Hz: *-8.4dB*

Date: *24-1-2005 13:47*
Operator: *Joachim Dietz*

The step response diagram on the right was obtained from the differential equation.