10.1.1.1. SINGLE-CHANNEL ACCELEROMETER WITH INTEGRATED LOW-FREQUENCY FILTER

AKSEL

PROPERTIES SHOWN

Serves for frequency filtration of an acceleration plot of a physical point obtained by calculation or experimentally.

The internal structure of the filter is shown in the Figure DAKSEL_1.a. The signal supplied to the filter input passes through the oscillatory circuit k - m_1 - μ_1. The purpose of this circuit is to ensure the minimum signal distortion in the frequency range 0... *Fh*, where *Fh* is the frequency numerically equal to the filtration class of the channel. The signal then passes through the viscous inertial filter μ_2 - m_2 that ensures meeting the filter requirements at the frequencies which exceed the band edge *Fn*.

The element model can be used for processing the impact test results and meets the requirements of the ISO 6487-80 standard ("Measurement techniques in impact tests. Instrumentation.").

The static frequency response of the filter is shown in the Figure DAKSEL_1.b. The hatched zone shown in the figure is the zone of the permissible frequency response according to the requirements of the ISO 6487-80 standard.

After the signal passes through the filter it phase shift occurs. The ISO 6487-80 standard establishes the limitations for the difference between the frequencies 0.03 *Fh* and *Fh*. It shall not exceed the value of 1/(10*Fh*). For the four filtration classes defined by the standard the element model gives the following results for the phase shift at the frequencies 0.03*Fh* and *Fh*:

Channel frequency class	Sec (ms)		Difference in phase shift (ms)	
	frequency 0.03*Fh*	frequency *Fh*	calculated	ISO 6487-80 requirement
60	3.48	3.52	0.04	1.67
180	1.16	1.18	0.02	0.56
600	0.34	0.36	0.02	0.17
1000	0.22	0.22	0.00	0.10

DEGREES OF FREEDOM

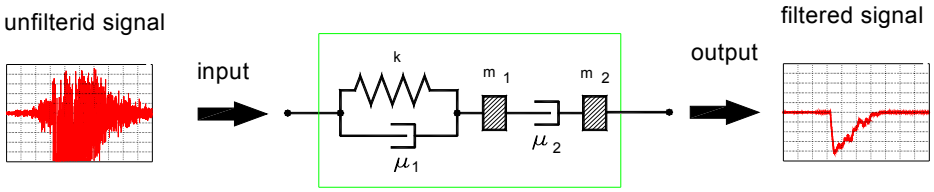
1 - translational, of the point the acceleration of which is being measured;

2 - translational, of the accelerometer sensing element.

PARAMETERS

No.	Description	Unit	Range
1	Frequency class of the filtration channel *Fh*	*hertz*	*0 ... +RLmax*
2	Band edge *Fn*	*hertz*	*Fh ... +RLmax*
3	Sensor initial speed	*m/sec*	*-RLmax... +RLmax*

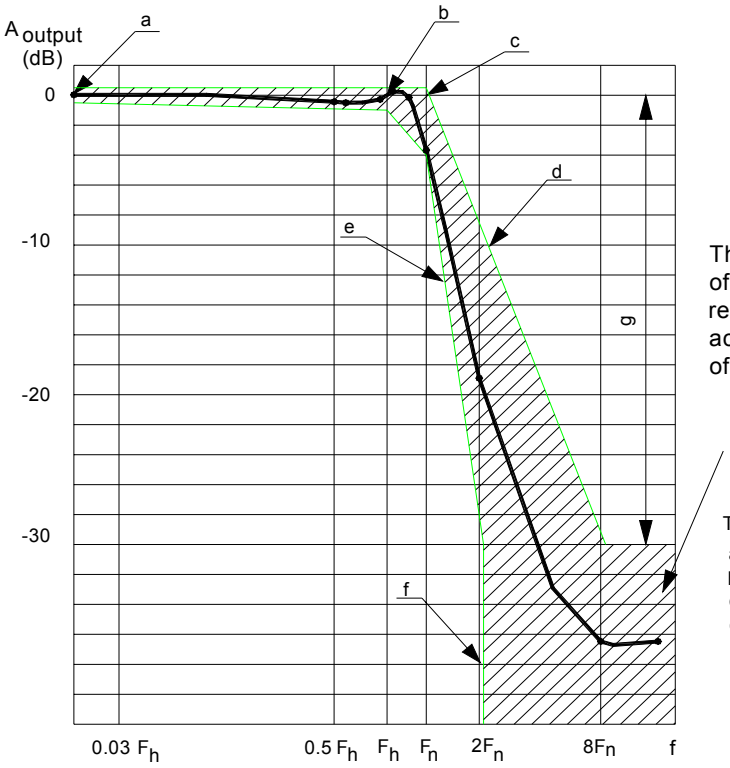
low frequency filter model (AKSEL)



NOTE

1. $m_1 + m_2 = m_{acc} < 0.001$ gr
2. The parameters of the oscillatory circuit k and μ_1 selected to achive the minimum signal distortion at frequency F_h
3. The characteristic of the damper μ_2 is determined by the filter requirements for frequencies that exceed the band edge F_n

b)



The hatched zone is the zone of the permissible frequency response of the filtration according to the requirements of the ISO 6487-80 standard

The graph shows:

a	+ 0.5; - 0.5 dB
b	+ 0.5; - 1 dB
c	+ 0.5; - 4 dB
d	- 9 dB per octave
e	- 24 dB per octave
f	∞
g	- 30 dB

AKSEL_1 Low-frequency filter for acceleration measurement channel
a) filter schematic
b) filter frequency response
Fh - channel frequency class
Fn - band edge

Notes:

1. The standard classes of the filtration channels provided for by the ISO 6487-80 standard: 60 hertz (band edge 100 hertz), 180 (300), 600 (1000), 1000(1650).

2. The element can be used for measurement of acceleration of the degree of freedom having non-zero initial speed. The parameter "Sensor initial speed" is provided for such cases as the element has an internal degree of freedom.

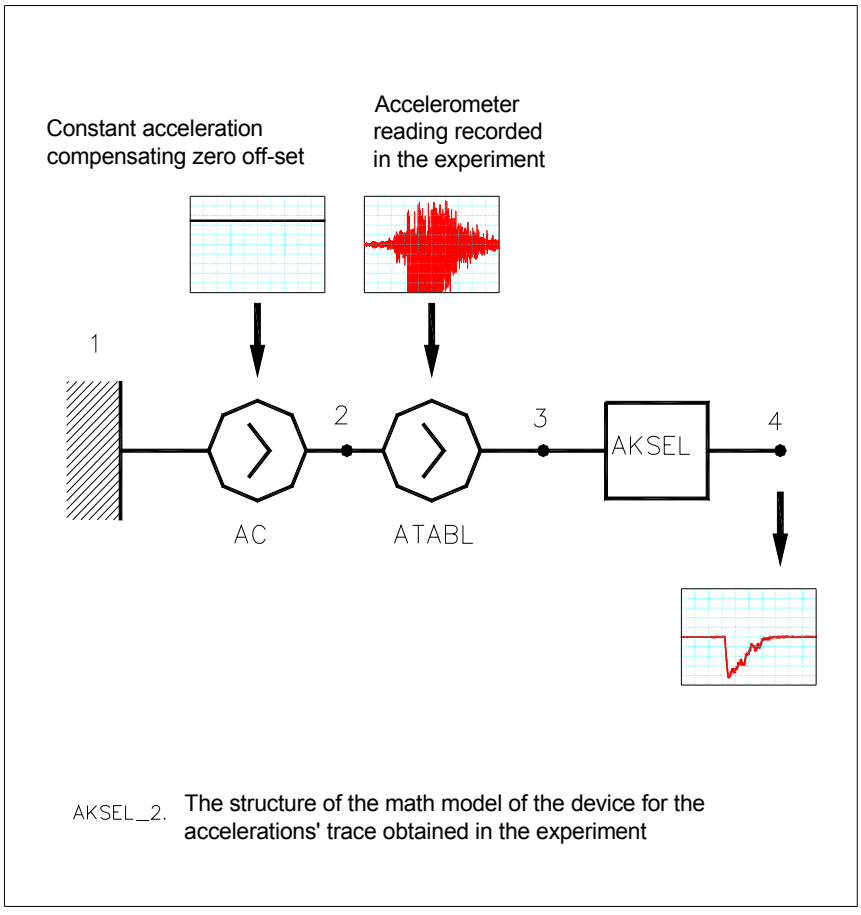
3. The internal mass of the element is 0.001 g.

APPLICATION EXAMPLE

A file containing the data of acceleration change versus time is available. A fragment of the file looks as follows :

```
{time} {acceleration}

0.000000,   0.,
0.004778,   0.499847,
0.004875,   0.397838,
0.004973,   0.295829,
0.005070,   0.193820,
0.005168, -0.010198,
   . . .
```



AKSEL_2. The structure of the math model of the device for the accelerations' trace obtained in the experiment

The acceleration graph needs to be filtered by a filter having the frequency class of the filtration channel 60 Hz. We then need the relation of the speed and acceleration versus time and replot the speed and acceleration versus time graphs to show the same versus displacement.

For solving this problem the filtration channel with the set-up shown in the Figure AKSEL_2 is proposed.

The purpose of the elements of the set-up:

AC - the compensating acceleration source (for the elimination of the setting error of the acceleration graph zero line);

ATABL – the source of the table relationship of the acceleration versus time that reproduces the acceleration versus time relationship obtained in the experiment;

AKSEL - the accelerometer with the integrated filtration channel.

The text of the task in *PradiSLang*:

```
$ DATA:
   Table of acceleration   =
     $ INCLUDE: TEST.DAT
   Initial velocity     =   5.0
   Compensating acceleration  =   0
   Fh        =  60
   Fn        = 100
$ FRAGMENT :
   # BASE : 1
   # STRUCT :
      Experimental acceleration 'ATABL (3 2;
                                  Table of acceleration   )
      A comp          'AC    (  2;
                                  Compensating acceleration  ,100)
      Filter channel        'AKSEL (3 4;
                                  Fh,
                                  Fn,
                                  Initial velocity)
   # OUTPUT:
      Accel NF    'X (3";1)
      Velocity NF 'X (3';1)
      Displacement NF 'X (3 ;1)
      Accel filtered        'X (4";1)
      Velocity filtered     'X (4';1)
      Displacement filtered 'X (4 ;1)
$ RUN:
   Processing 'NEWMARK (END=0.3, SCALE=1;
                    Accel NF, Accel filtered)
$ PRINT:
   Filter 60          'ACAD (;
                             Accel NF      = (-5500, 2500),
                             Accel filtered= ( 0,    2000)  )
   V and  A from  S          'ACAD (FROM=1;
                             Displacement filtered = (-0.75, -0.5),
                             Velocity filtered    = (-100, 100),
                             Accel filtered )
$END
```

An example of the filtration results and the plot of acceleration and speed versus displacement are shown in the Figure AKSEL_3.

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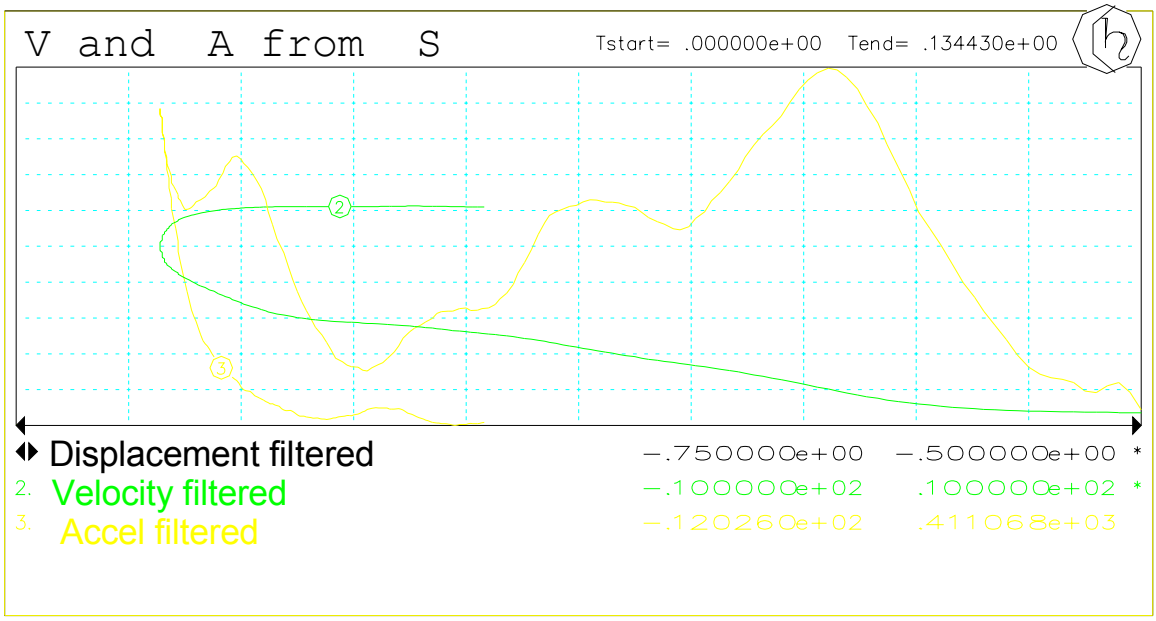

AKSEL_3. The example of processing of experiment results
a) original and filtered relationship of acceleration versus time
b) replotted relationships of acceleration and speed versus displacement