User Manual for the Family of Acoustic Emission Signal Conditioners ASCO-PXx

Contents:

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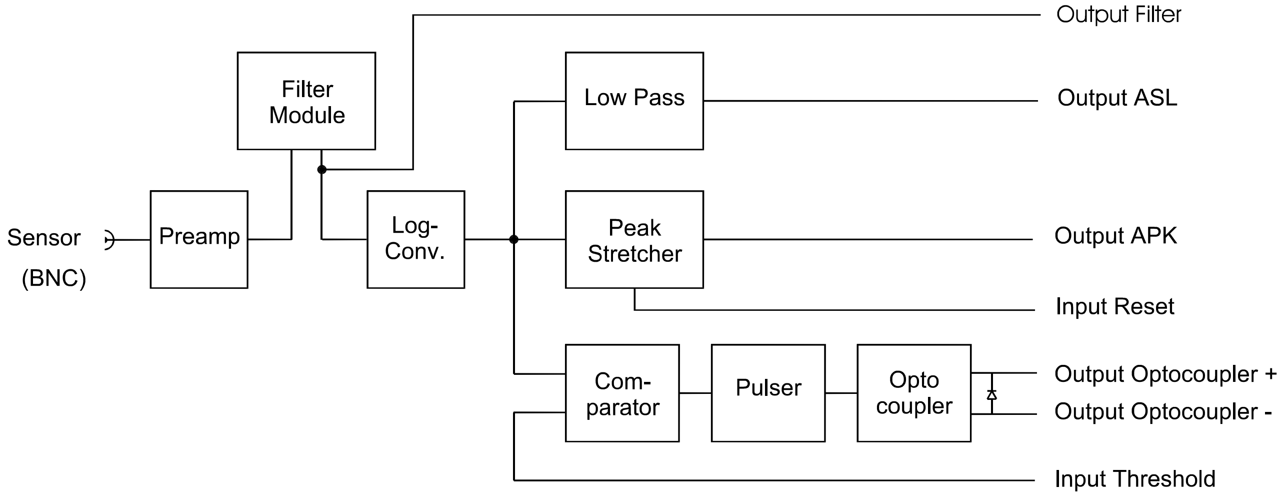
1 Applications

The ASCO-P (Acoustic Signal Conditioner with Peak Detector) lets you detect damage mechanisms, such as crack formation, crack growth, fiber breakage, delamination, debonding of surfaces and others, **as they happen!** This works with all brittle materials, e.g. fiber reinforced plastics, composites, ceramics, metals and many more. In addition, the ASCO-P can detect and monitor leaks, partial discharge, particle impact, flow turbulences, friction, corrosion and more.

The ASCO-P conditions the AE signal such that it can be recorded and evaluated by using a low-cost PC plug-in data acquisition card and a minimum of software that shows voltage over time. **With ASCO-P the integration of AE measurements into an industrial application becomes straight forward and very cost effective.** The ASCO-P forms a very useful completion of your mechanical testing machine (tensile, bending, scratch tests etc.) because it provides valuable information on the damage process in your sample with very little effort.

2 Blockdiagram



The AE signal (delivered by a piezo-electrical AE-sensor) is fed-in over a BNC-connector and amplified by a low noise preamplifier. A filter module rejects undesired frequency components. The high frequency signal is rectified and the logarithm is obtained. This signal is smoothened by a low pass filter and presented at the Output ASL (average signal level). In parallel, the logarithm signal is processed by a peak-stretcher which holds even very short peak values for a defined time period and presents it at the Output APK (AE peak amplitude). The log signal is compared against a threshold fed-in as analogue voltage (e.g. the analogue output of a PC card). When the signal exceeds the selected threshold a pulse is generated, fed over an optocoupler and presented at the pins Optocoupler+ and Optocoupler-. Depending on the application this can trigger e.g. an alarm, or an image record, an event counter, or a more detailed analysis of the incoming data.

3 Sensors

For the detection of rapid changes in the material, such as crack formation and growth, fracture, partial discharge, etc., we recommend our sensor VS150-M which has the peak sensitivity at 150kHz. For the detection of leak or friction in the range 25 to 80kHz, we recommend the VS30-V. For high frequencies up to 1.3MHz, e.g. from thin fiber reinforced materials or paper the VS700-D is well suited.
In order to meet special requirements, for instance high temperatures, different sensors have to be chosen. Sensor and the model of the ASCO-P family have to be chosen according to the frequency range of interest.

4 ASCO-P Derivatives

ASCO-P is available in derivatives to cover different frequency ranges.

4.1 Overview of ASCO-P Derivatives

4.1.1 ASCO-P1

This derivative is still available for customers using this version and want to stick to this version.

4.1.2 ASCO-PNx, PHx

The derivatives ASCO-PNx und PHx are successors of the ASCO-P1. They differ from ASCO-P1 with respect to the low-pass at the ASL-Output. For the ASCO-P1 this low-pass is 2-pole 50Hz, for ASCO-PNx and –PHx this low pass is 1-pole 86Hz. The 1-pole filter allows the determination of an energy-proportional result for each detection interval. An optimum is reached for 5000 Scans/s. For such a high sample rate we recommend to enable the short PST (Peak Stretching Time) by removing jumper JP2. This also allows to resolve hit rates up to 1000/s and more.

4.1.3 ASCO-PHx

With the ASCO-PHx the usable frequency range is 90 to 1300kHz. In addition to the higher frequency range this derivative realizes a considerably shorter rise time of the APK-Output (7µs instead of 25µs). This implies an increased electric noise. For higher frequencies we recommend higher sampling rates and also the shorter PST.

4.2 Properties of ASCO-P Derivatives (typical)

Derivative	frequency range [kHz]	APK-rise time [µs]	ASL noise 50R [V]	APK noise 50R [V]	ASL noise 50R [dB]	APK noise 50R [dB]	ASL-filter
ASCO-P1	90-295	25µs	0,654	0,948	16,4	23,7	2-pole 50Hz
ASCO-PN1	90-295	25µs	0,654	0,948	16,4	23,7	1-pole 86Hz
ASCO-PN2	20-84	25µs	0,428	0,591	10,7	14,8	1-pole 86Hz
ASCO-PH3	240-710	7µs	0,935	1,347	23,4	33,7	1-pole 86Hz
ASCO-PH5	90-1300	7µs	0,971	1,243	24,3	31,1	1-pole 86Hz

4.3 Property „APK-ASL“

APK and ASL are derived from the same logarithmic output, but APK represents the peak amplitude and ASL the average. The average is gained by a smoothing low-pass. This causes a difference between the levels of APK (e.g. of a sineburst) and ASL (e.g. a continuous sinewave) which increases with decreasing frequency. The following table shows this difference at 2 frequencies for each ASCO-P derivative: at the so-called testing frequency and half the testing frequency. Each ASCO-P derivative is adjusted such that the APK Output at the testing frequency is optimized for lowest deviation from the input (burst) signal. The testing protocol coming with the ASCO-P shows (among others) the frequency dependence of the APK output and the difference „APK-ASL“ (example below). Negative values for APK-ASL appear, if the APK risetime hinders the APK level to reach the peak level. For the measurement of short bursts of frequencies above 300kHz we recommend the derivatives ASCO-PHx.

Derivative	Frequency range [kHz]	Test frequency [kHz]	APK-ASL [dB] at test frequency	APK-ASL [dB] at 0,5*test frequency
ASCO-P1	90-295	200	0dB	0,7dB
ASCO-PN1	90-295	200	0dB	0,7dB
ASCO-PN2	20-84	60	1,3dB	2,7dB
ASCO-PH3	240-710	500	0,6	2,1
ASCO-PH5	90-1300	500	0,6	2,2

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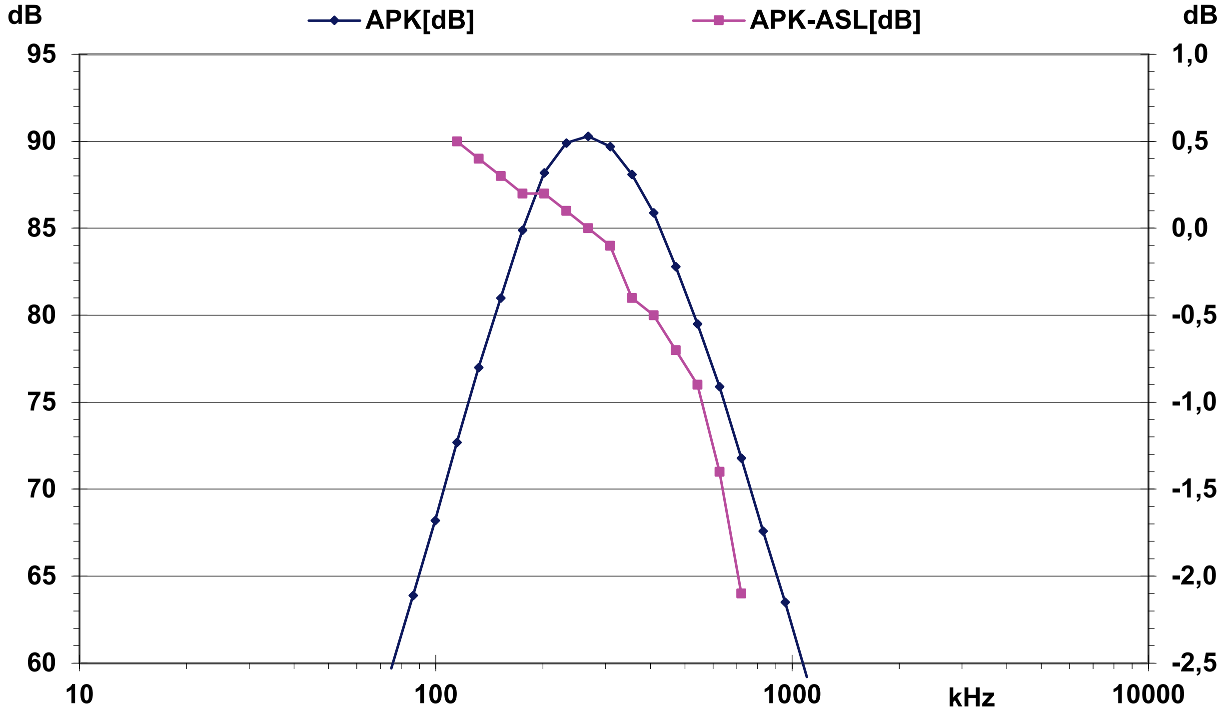
Example for frequency dependence of APK and APK-ASL (ASCO-PN1), as shown in the testing protocol:



5 Specifications of ASCO-Pxx

Derivative overview in paragraph 4.

5.1 AE-Preamplifier (sensor-connector):

Input impedance:	>10MOhm parallel 10pF
Meas.range:	±100mV$_{PK}$ = 100dB$_{AE}$
Gain:	20dB
Noise (Inp.50R):	P1, PN1:24dB$_{AE}$ PN2: 16dB$_{AE}$ PHx: 34dB$_{AE}$
Freq. range [kHz]:	P1, PN1: 90-290 PN2:20-85, PH3:240-710, PH5: 90-1300
Filter roll-off:	high-pass 24dB/Octave, low-pass 12dB/Octave
Characteristic:	Butterworth,

5.2 Threshold-Input:

Voltage:	like ASL, Ri = 10kOhm

5.3 Filter Output:

Voltage:	approx. 2V$_{PP}$ @ 100dB$_{AE}$ equals 0.2V$_{PP}$ @ sensor
Max. load:	5mA

5.4 APK-Output: (Peak-Amplitude)

Voltage:	4,0V @ 100dB$_{AE,}$ 200kHz 40mV/dB$_{AE}$,<10mA
Rise time (-3dB):	P1, PNx: 25µs, PHx: 7µs (sine burst excitation)
Peak-Stretching:	51ms from last amplitude increase. 0,5ms w/o. jumper.
Fehler:	±1dB (40-95dB$_{AE}$, PHx:45-100)

5.5 ASL-Output: (Average Signal Level)

Voltage:	40mV/dB$_{AE}$ <10mA
APK-ASL-Offset:	P1, PN1: 0/0,7dB @200/100kHz; PN2: 1,3/2,7dB@60/30kHz PH3, PH5: 0,6/2,2@500/250kHz
Smoothing low-pass:	P1: 50Hz, 12dB/Octave, PNx, PHx: 86Hz 6dB/Octave
Error:	±1dB (35-95dB$_{AE}$)

5.6 Reset Input:

2-5V or open:	Peak Stretching: normal
0V:	Peak Stretching: off

5.7 Opto-Output:

normal:	open (5V max)
activated:	at threshold-crossing (see para.8)
Pulse duration:	52-62ms, no post-trigger

5.8 Supply Voltage:

Voltage:	7-15V$_{DC}$ Low Noise!
Power consumption:	max. 100mA
Power feed in:	SubD 15 (female)or jack plug
Control:	internal to +5V

5.9 Connectors (ASCO-side):

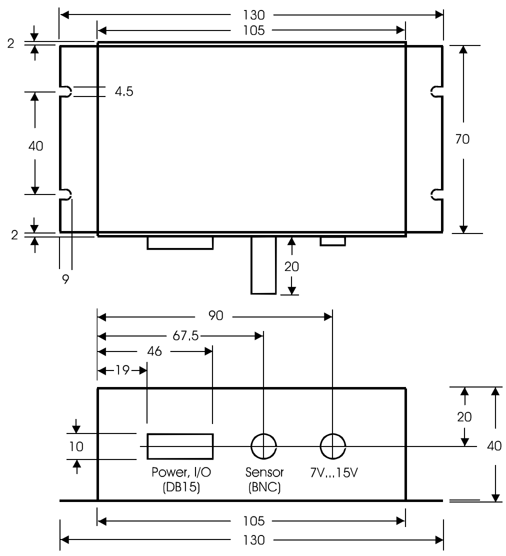
A. BNC-socket: AE-sensor (e.g. VS150-M)

B. 5.5/2.1mm jack plug: Power supply (7-15V$_{DC}$, plus at inner, minus at outer pole)

C. 15-pole D-connector, male (see block diagram)

Pin 1:	Power +7 to 15V$_{DC}$ (0V: pin 9)
Pin 2:	Internal Pullup to 5V (see chapter 12)
Pin 3:	Optocoupler +
Pin 4:	Output APK (0-4V)
Pin 5:	Input Threshold (0-4.24V)
Pin 6:	Input Reset (0-5V)
Pin 7:	do not connect, for manufacturer test only
Pin 8:	Output ASL (0-4.24V)
Pin 9:	GND / Power -
Pin 10:	Optocoupler -
Pin 11-14:	GND / Power -
Pin 15:	Output Filter(2V$_{PP}$ @100 dB$_{AE}$)

5.10 Housing: (aluminium profile)



Spezifications are subject to change as developments are made.

Weight:	300g

5.11 Environment conditions:

Temperature range:	-30 to +70°C
Humidity:	0-90% not condensing

5.12 Accessories available:

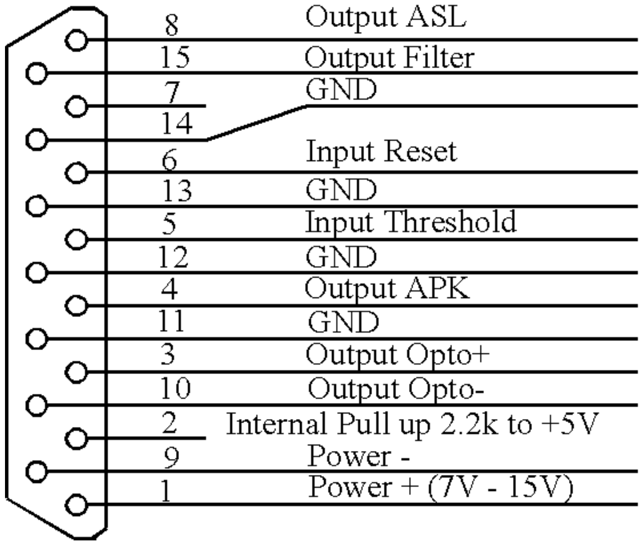
ASCO-NTE:	Power supply for 230V$_{AC}$
CBL-2-1M5-V8:	Cable D-Sub15pol. to 2*BNC (APK and ASL)
CBL-3-1M5-V9:	Cable D-Sub15pol. to 3*BNC (APK, ASL, Output Filter)

For sensors, modifications, special versions or PC integration, please contact us.

Specifications subject to change as product developments made.

6 I/O-Connector Pinout

15pol SUB-D



With Reset Input low, the peak-stretcher output (APK Out) follows the logarithmic output without delay. Reset Input is usually open. For handshake with a microprocessor.

Threshold Input can stay open if Opto Out not used. Threshold does not influence ASL Out or APK Out.

Opto Out- can be connected to GND (Pin 11), Opto Out+ to the Pull-Up resistor (Pin 2), if the isolation is not desired.

Power- and Power+ are in parallel to the separate 5.5mm power socket (connecting jack plug not required if I/O-connector is used for power supply).

Male connector at ASCO-P, female at cable.

7 Modification of the Peak-Stretcher-Time

The APK-Out signal is clamped to the highest peak amplitude for the duration of the Peak-Stretching-Time to enable a relatively slow and low-cost data acquisition system to measure very short AE-peak amplitudes over a very large dynamic range.

The Peak-Stretching-Time comes usually set to 51-53ms (adjustable at pot. P3). Removing jumper JP2 disconnects C43 and shortens the Peak-Stretching-Time to about 0.5ms. Values between can be realized by modfiying C43/C431. By enlarging R25, stretching times up to 1 second and more can be achieved.

Peak-Hold-Time (ms)	R25	C43	C431	Jumper JP2
51	47kOhm	1µF / 35V Tantal factory setting	10nF factory setting	Inserted
1,5	47kOhm	not used	33nF	Open
0,5	47kOhm	not used	10nF factory setting	Open

8 Modification of the Pulse Width (Opto-Coupling-Output)

ASCO-P comes with a pulse width of 52 to 62ms and can be modified as shown in the table:

Pulse Width (ms)	R30	C39
52-62	1.5MOhm	100nF
10	300kOhm.	100nF
1	30kOhm	100nF

The pulse width restarts with each threshold crossing. This can cause a larger pulse width.

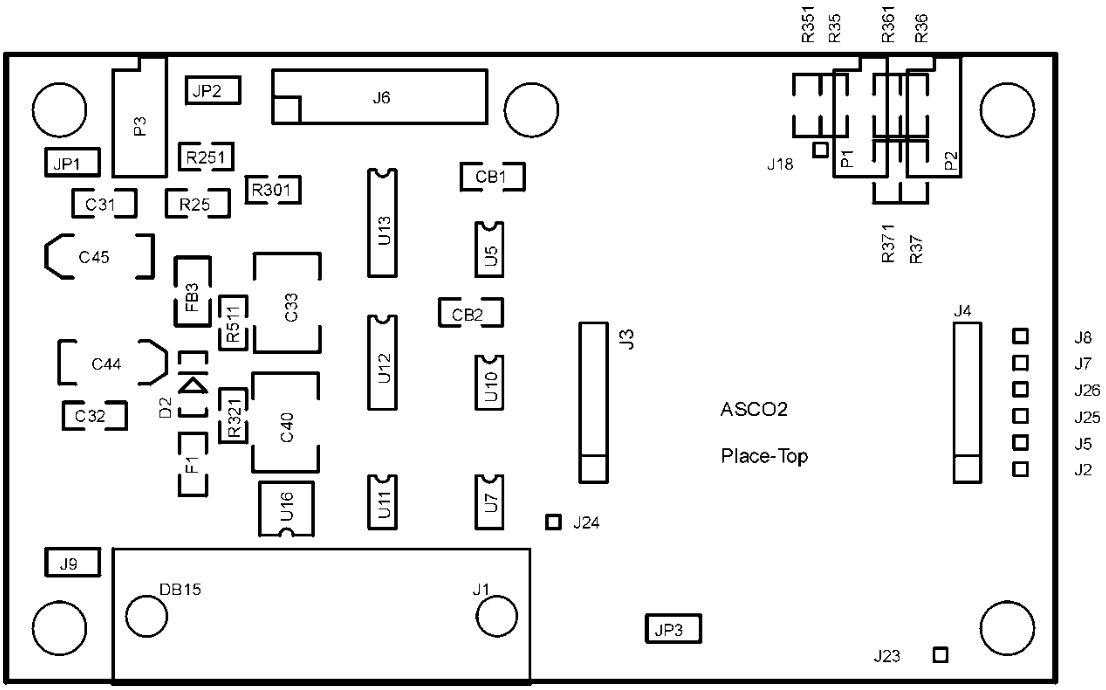
All resistors are of model SMD 1206, 1% metal film, all capacitors SMD 1206, 5%, COG. (if values are not produced from COG, material: X7R (10%, higher temperature coefficient).

9 Adjustments (not recommended without being trained)

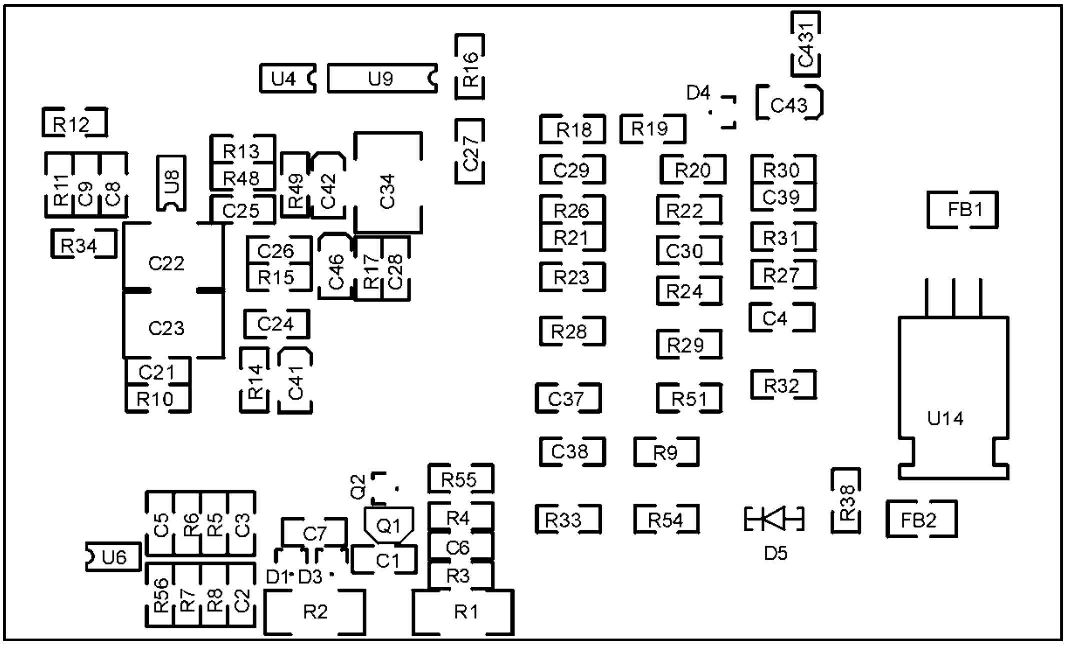
P1: turn right to increase slope of logarithm curve (should be: 40mV/dB)
P2: turn right to shift up logarithm curve (should show: 3,6V @ $90dB_{AE}$ input)
P3: turn right to increase Peak-Stretching-Time

10 Component Location on the Printed Circuit Board

10.1 Top side: (R251, R301 not inserted. Parallel to R25, R30 for easy modification)



10.2 Bottom side:



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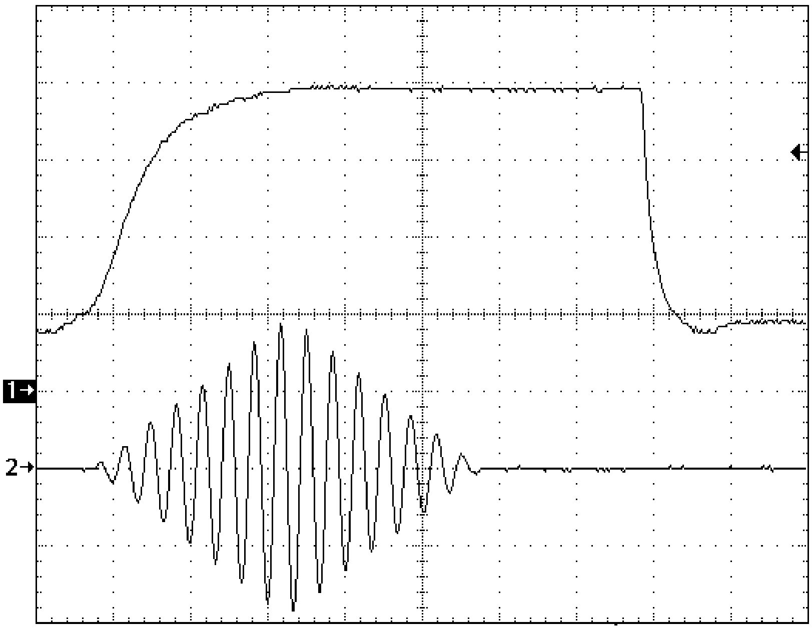
11 Details on ASCO-P Results

11.1 APK Acoustic Peak



CH1: Peak-Stretcher Output 1V/Div Time 20µs/Div
CH2: Signal Input 50mV/Div Time 20µs/Div

Top signal (chan 1):
APK (Peak Stretcher Output)

Lower signal (chan2):
Input signal generated by ACAL3 AE-calibrator

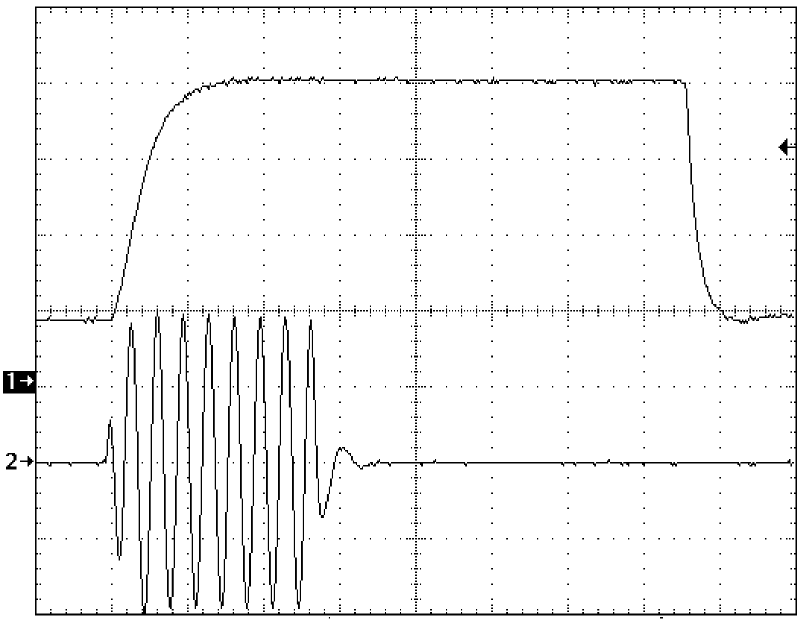
For better understanding, the peak stretching time has been shortened to about 80 µs. APK starts at 800mV which corresponds to $20dB_{AE}$ (40mV/dB) or 10µV input which was the noise level of the calibrator.
The maximum peak amplitude of 100mV corresponds to $100dB_{AE}$ which is converted to 4V (40mV/dB). This level is kept constant during the peak-stretching time.
This example demonstrates the ASCO's very high dynamic range of 80dB.

Picture on the right:

Like above, but the gated sine wave input demonstrates the rise time of the ASCO-P.

Derivatives P1 und PNx have an APK rise time of 25µs
(-3dB/-120mV point with 90dB step).

Derivatives PHx have 7µs rise time and extend the frequency range to higher values (thereby increasing the noise).
For detecting very short spikes (e.g. AE from paper) we recommend the **ASCO-PH5** (90-1300kHz).



CH1: Peak-Stretcher Output 1V/Div Time 20µs/Div
CH2: Signal Input 50mV/Div Time 20µs/Div

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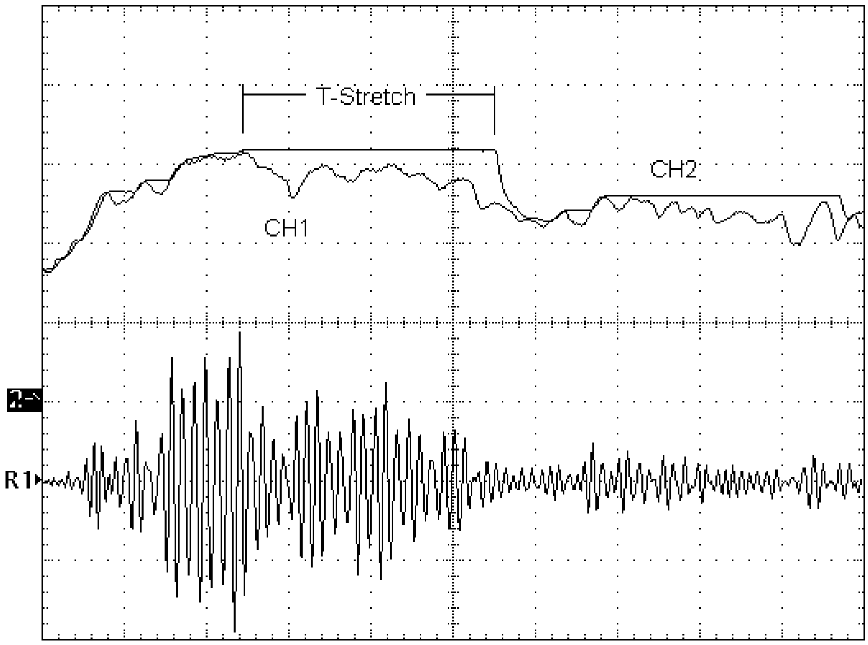


CH1:	Peak-Stretcher Input	1V/Div	Time 50µs/Div
Ch2:	Peak-Stretcher Output	1V/Div	Time 50µs/Div
R1:	Sensor Signal Input	5mV/Div	Time 50µs/Div

Top signal (Ch2):
APK (Peak-Stretching Output)

Below (Ch1):
Internal logarithmic envelope signal, (Peak-Stretching Input)

Lowest curve (R1):
Sensor signal.

The picture on the left shows the response of the APK output to an AE-sensor signal. Peak-Stretching Time for better demonstration shortened to about 150µs.

The input peak amplitude of 10mV (80dB$_{AE}$) is converted to 3.2V output (40mV/dB *80dB$_{AE}$ => 3.2V)

11.2 ASL Average Signal Level

The ASL is a measure for the averaged signal level and somehow related with the energy.
The ASL is obtained from the sensor signal by (see also block diagram on page 2):
a) first preamplifying the signal to optimize the signal-to-noise ratio
b) next applying a frequency filter (letting pass only the desired frequency range, e.g. 90-295kHz)
c) then rectifying the filtered signal and converting it to a logarithmic representation (to cope with the huge dynamic of AE signals)
d) and feeding this over a low pass filter

The output of the low pass filter is what you get as ASL signal.

Basically the low pass is a combination of resistor (R) and capacitor (C). Such a combination has a time constant (Tc), defined as: Tc=R*C

The frequency limit (f) of this combination is defined: f = 1/(2*PI*R*C) = 1/(2*PI*Tc)
With PI = 3.14159...

From this one can derive Tc= 1/(2*PI*f)
=> low pass of 50Hz: Tc = 3,18ms
=> low pass of 86Hz: Tc = 1,8ms

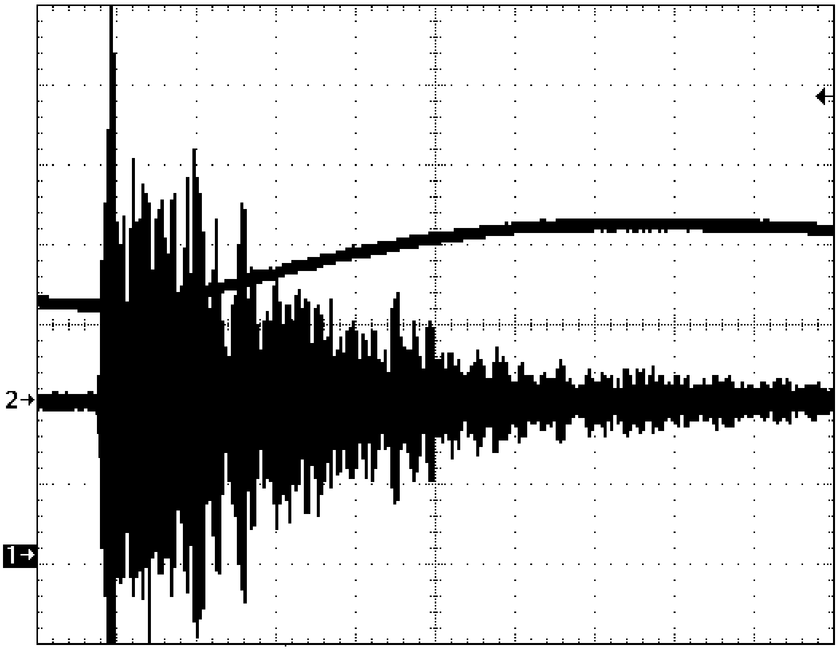
That means the averaging is done with a time constant of 3,18ms or 1,8ms respectively.

Upper curve: ASL-Output
Lower curve: Sensor signal

Low-passing the 'logarithmic envelope' provides the ASL-Output.
As the pictures shows, the ASL signal follows input changes with delay. The **ASL**-Output therefore is suited to analyse continuous signals, e.g. from leakage.

In contrast, the APK output is suited to indicate signals from rapid changes, such as cracks, fracture, partial discharge and more.

For the energy analysis of short bursts the derivatives **ASCO-PNx** and **-PHx** are optimized.



CH1:	ASL Output	500mV/Div	Time 500µs/Div
CH2:	Sensor Signal Input	20mV/Div	Time 500µs/Div

The combination of both outputs (ASL and APK) in one module makes the ASCO-P a very versatile AE-frontend module.

12 How to start

12.1 General

The ASCO-P as well as the sensor are high-tech components. In order to avoid damage, prevent them from mechanical shock (e.g. do not drop them on the floor).

12.2 Connections

The ASCO-P requires a 7V ... 15V DC low noise power supply. We recommend to use a linearly regulated power supply rather than a so-called "switched" power supply, on reasons of lower noise. You can supply this voltage to the ASCO-P either via the jack plug or via the 15pol Sub-D connector (for details see section 5). If it is ordered, we also supply the cable to connect the sensor to the BNC-connector of the ASCO-P. The sensor to ASCO-P cable is sensitive to folding and pulling from the connectors.
Data output is the 15pol Sub-D connector of the ASCO-P. You can use the enclosed cable (supplied only if ordered) to make the APK and ASL signal available at separate BNC-connectors (female). You may also have a cable customized to fit your data acquisition system.
Minimum requirements for the data acquisition system for use with the ASCO-P: analogue DC input 0-4V. The required sampling rate and settling time depends on the selected Peak Stretching Time (PST):
For 50ms PST, 50Hz sampling rate and 20ms settling time are sufficient. For 0.5ms PST, 5000Hz and 0,2ms settling time are recommended. If your data acquisition system has a low pass filter it should not show overshooting. (The term "settling time" defines the delay the data acquisition output needs to follow a step wise change of the input signal with desired accuracy)

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12.3 Sensor-Coupling

The active area of the sensor (the white ceramic plate in case of the VS150-M) and the area of your sample where the sensor is to be placed should be as clean as possible. It is of particular importance to wipe off "grains" such as dust, sand, or metallic particles.
The sensor shall be coupled to the sample using a thin layer of couplant. Layer thickness less than 0.1mm is desired. Put some couplant on the sensitive area of the sensor, then press it (force: 5-50N) against the sample while slightly moving it (approx. +/-2mm). Couplants that are most commonly used are grease (temporary) or silicon adhesive (for permanent installation). For long time tests, be sure that the couplant is one that does not evaporate or change its properties (e.g. due to temperature or chemical interaction). Avoid using couplants that form brittle bonds; these may generate AE-signals when the structure deforms under test loading.
The sensor should be pressed against the sample by an elastic force of about 5 to 50 N (we offer magnet hold-downs for sensor mounting on ferritic materials). Avoid electrical contact between the metallic sensor housing and any conducting surface (for instance, metal samples); contact between the housing and conducting surfaces result in ground loops which are a source of electrical noise.
Check the coupling by breaking a pencil lead about 3cm away from the sensor: An inclined angle (approx. 30°) between the sample surface and pencil is usually best. Gently press until the lead breaks. The corresponding APK signal should correspond to 90dB minimum on most test structures (on extremely thick parts, amplitudes from a pencil lead break may be slightly less). If the amplitude of the APK signal is too low, please remove the sensor, remount the sensor (including the coupling) and repeat the sensor check.

12.4 Testing Environment and Noise

The ASCO-P in combination with an AE sensor is an extremely sensitive measurement instrument. It will detect small acoustic signals (elastic waves) in your sample in the filtered frequency range. Try to acoustically isolate your sample against unwanted external influences.

12.5 First Analysis

We recommend for a first, simple analysis to display the ASCO-P output against time and – if available – against external parameters (such as load, distance, number of cycles, etc.). To investigate if a certain process (e.g. crack growth, delamination, leakage, etc.) can be detected by the ASCO-P we recommend the following two sample tests. In test one, take a sample that follows or contains a known process and in the second test take one which is known not to follow or contain this process. Comparing the data should simply indicate if the ASCO-P is suited to detect this process in your very special application.
For ASCO-P we provide an easy to operate but versatile data acquisition module well suited for many process monitoring applications: **ASCO-DAQ2**. Connected to a PC using the standard USB 2.x interface the 4-channel data acquisition module samples APK, ASL, external parameters like stress, strain, pressure, temperature, etc at a programmable sampling rate and stores the data to file.
ASCO-DAQ2 comes with ready-to-use powerful **AscoDaq** software package for data acquisition and analysis including automated monitoring and alarm modes.

13 Conformity UKCA (UK Conformity Assessed)

Even though the product might not show on its chassis the UKCA symbol it is UK Conformity Assessed (UKCA).

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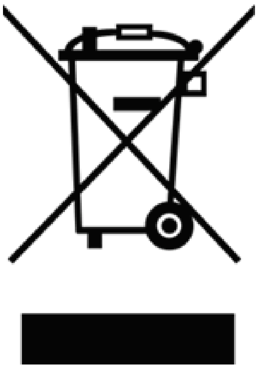
14 Redemption and Disposal Information of Used Vallen Equipment



- Equipment labelled with the symbol shown left must be disposed separately from unsorted municipal waste within the European Union.
- Owners of old instruments request our agreement to return old electronic equipment. The goods to be returned must be described unambiguously and identified by serial and/or identification number. You can fill in our contact form (www.vallen.de/contact/) or send us an email to sales@vallen.de.
- Upon our approval owners may ship the goods free of costs to us.
- We will dispose the goods according to the relevant laws and regulations on our costs.
- Goods returned without our approval will not be accepted and returned to the owner on his account.
- We explicitly point out that according to § 19a ElektroG3 you are responsible to delete any personal data on the appliances considered for disposal.

More information can be found under www.vallen.de/products/services/.

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