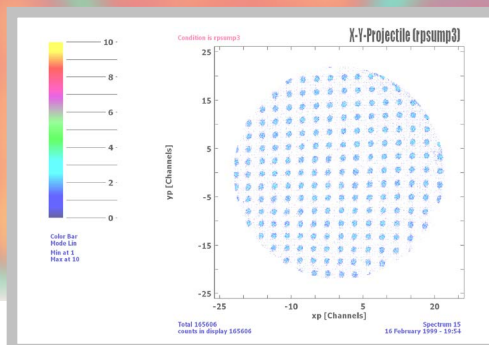
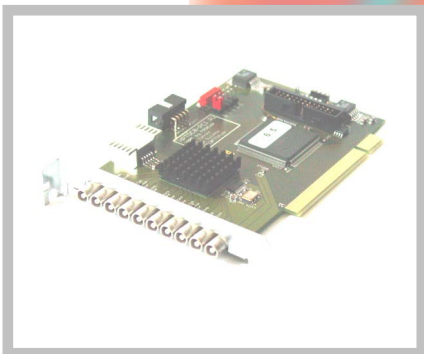
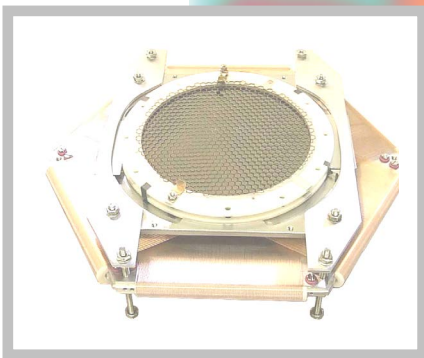


The **RoentDek** (B)FAMP8(c), (D)FAMP6(L), PreFAMP6, FAMP3, FAMP1+, BFAMP3 and BFAMP1

(11.0.1911.1)



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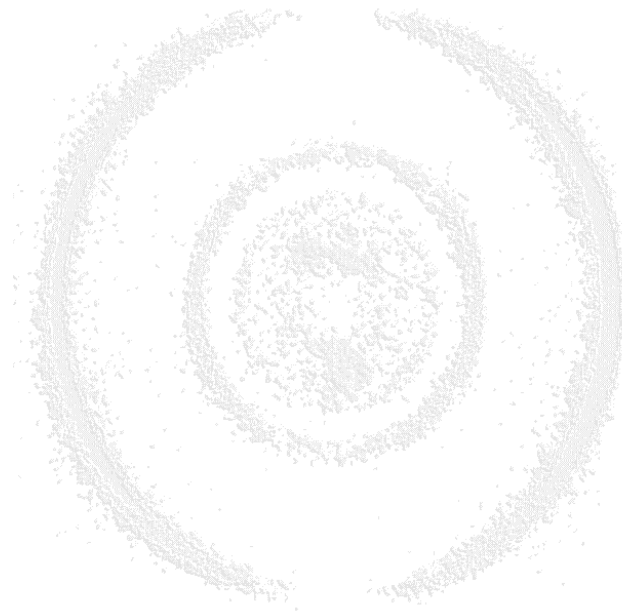
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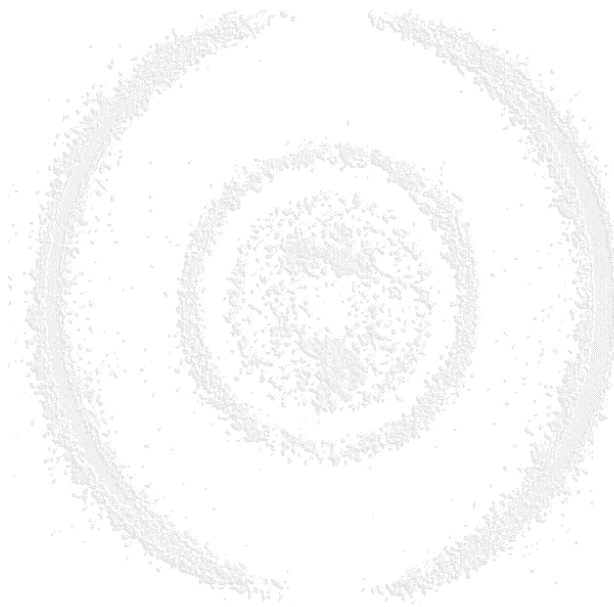
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3a The FAMP Amplifier Modules

The readout of the MCP, timing and delay-line anodes as from **RoentDek** detectors or from similar single particle/photon counting detector devices requires *amplifying* signals before they can be routed to timing (discrimination) and digitizing circuits. The **RoentDek** FAMP units are used to amplify input signals of adequate impedance with pulse heights from noise level to 100 mV (any polarity). Signal amplification will be linear as long as the gain is selected to keep output pulse heights within specifications. The amplifier circuits can produce output pulse heights up to about 2 V before reaching saturation, however, their linear response is limited to signals with up to ± 1.5 V output pulse height. The output signals are then suitable for further processing with fast analog digitizer units like the **RoentDek** fADC models or with the combination of “*Constant-Fraction Discriminators*” (e.g. the **RoentDek** CFD models) and a time digitizer like the **RoentDek** TDC8HP or TDC4HM.

This manual describes the different units of the two **RoentDek** amplifier families FAMP8/1+ and (Pre)FAMP6/3(b), also in the BFAMP version with reshaped (bipolar) output signals.

At this point a few facts common to all FAMP versions are to be mentioned: All units provide both inverting (“/OUT”) and non-inverting (“OUT”) outputs (on which gain may differ within up to 10 %. Values given for input impedance and gain are only approximate. Changing the gain via the potentiometers may also slightly alter input impedance and bandwidth. Some units allow bandwidth modification by exchanging internal circuits. The factory-set bandwidth limitation ensures specific *signal shaping* that is *crucial for optimal* performance of the **RoentDek** detectors, especially for imaging results with delay-line anodes. It is to note *that increasing the bandwidth does not necessarily improve the timing performance* but can instead destabilize the input circuit for enhanced *noise pickup, ringing, inter-channel cross talk and non-linear time response*. To minimise noise pickup, the outer case of the unit has to be well grounded and, as a precaution, no mains power supply (neither from **RoentDek** units or other modules) should be placed near the FAMP modules or the input signal cables.

3a.1 The amplifiers FAMP8(c) and FAMP1+

The **RoentDek** FAMP8 and FAMP1+ are stand-alone bipolar amplifier units for the amplification of high frequency pulse signals as obtained from micro-channel plate detectors, certain timing read-out anodes (e.g. delay-line) and various kinds of secondary electron amplifiers (photomultiplier, channeltron, etc.). The internal circuits of FAMP8 and FAMP1+ are almost identical.

3a.1.1 FAMP8 Amplifier

The **RoentDek** FAMP8 hosts 8 channels of bipolar amplifiers with a maximum bandwidth of 200 MHz on AC-coupled 50 Ω impedance input/output (LEMO 00 series sockets) in a 19" rack mount case (one height unit).

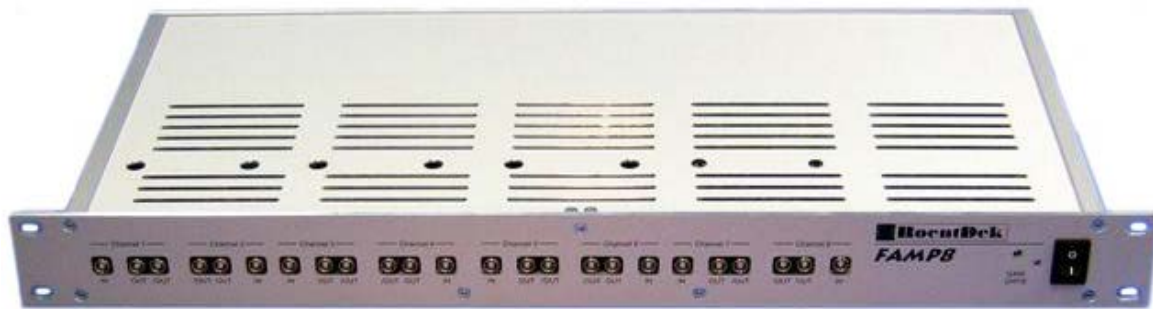


Figure 3.1a: FAMP8 module (mains power adapter not shown). The holes in the top lid here allow access to the on-board potentiometers for amplification gain adjustment of channels 1 to 6 (only older version).

The nominal amplification factor is about 70 and can be individually adjusted with individual potentiometers for six of the channels between 30 and 120 % and from 0 to 120 % for two of the channels (7+8) with one common potentiometer on the front panel (bandwidth and input impedance may vary at very low gain settings).

The FAMP8 has a power consumption of 30 Watt (2.5 A at +12 V) and is equipped with an over-temperature protection. It comes with an external power supply* for 100-250 V AC (50-60 Hz) mains power (typ. power consumption < 35 W). The

* No mains power supply (neither from **RoentDek** units or others modules) should be placed near the FAMP modules or the input signal cables to minimize the risk of EM-noise pickup.

dimensions are (approx.) 484 mm x 45 mm x 202 mm (width x height x depth) with an insertion depth (including power connector) of 262 mm, weight (without power adapter) is 1400 g.

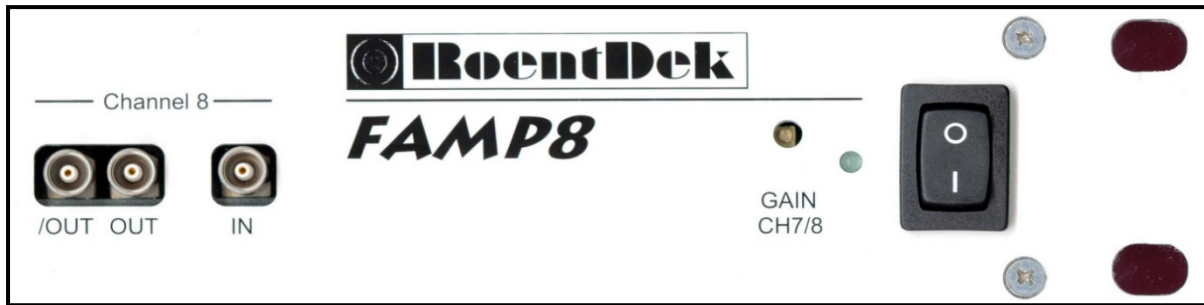


Figure 3.2a: Detail of the FAMP8 front panel with in-/output sockets for one channel and gain potentiometer.

3a.1.2 FAMP1+ Amplifier

The **RoentDek FAMP1+** is designed for the read-out of the **RoentDek DET40/75** and for the MCP signal off **RoentDek** delay-line detectors (as part of the **FEE2** front-end electronics assembly), after signal decoupling with an **FT4/12/16TP** unit or similar circuits.

The **FAMP1+** has identical functions as the **FAMP8** model on channel 7 and 8: The nominal gain is about 55 and can be adjusted with a potentiometer through the top lid from 0 to 110 %.

The unit has a power consumption of < 4 Watt (0.3 A at +12 V). It comes with an external power supply for 100-250 V AC (50-60 Hz) mains power (typ. power consumption < 5 W). The size is (approx.): 110 mm x 65 mm x 40 mm (width x height x depth) and weight is 300 g (without power adapter)

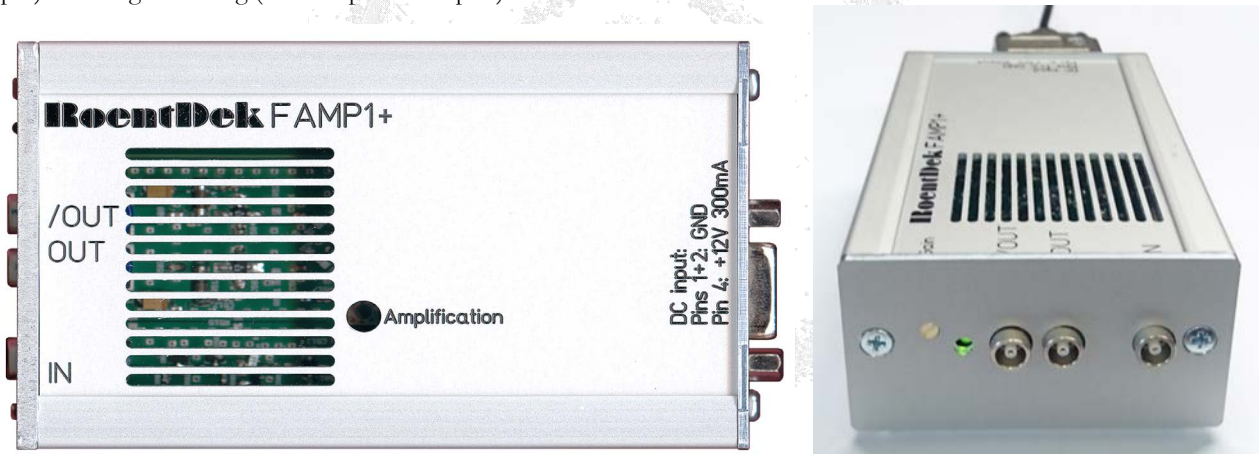


Figure 3.3a: FAMP1+, left picture with gain potentiometer on top lid, right picture: newer model with gain potentiometer on front panel. The FAMP1+ module is also available as 3HU unit for rack mounting (not shown).

The **FAMP1+** is designed for the read-out of the **RoentDek DET40/75** and for the MCP signal off **RoentDek** delay-line detectors, after signal decoupling with an **FT4/12/16TP** unit or similar circuits.

The default maximum bandwidth is factory set to 200 MHz. This bandwidth ensures that even narrow signals are amplified and shaped to a minimum width (> 2 ns FWHM) which is suitable for the follow up **RoentDek** timing electronics. Only for specific applications it may be changed to 300 MHz by removing capacitors on the internal circuit board (see Figure 3.4a). For opening the unit, please remove the two screws on the panel with the DC input (right side in Figure 3.3a). You may then pull out the internal circuit board with the panel attached to it and remove the gain adjustment board containing the potentiometer that sits on top of the circuit board.

To increase bandwidth, locate the limiting capacitor of the corresponding channel. On the **FAMP1+** circuit, it is labeled **C504 (FAMP8: C104/204/304/404)***. For removal place a solder iron (heated to 300 °C) with a fine tip alternatingly to each solder pad while securing the capacitor with tweezers. The capacitor can be removed if the solder on both contact pads is liquid.

* Since the **FAMP8** case is more difficult to open, **RoentDek** does not recommend that without prior consultation.

Make sure to *expose the circuit only locally to the minimum heat necessary* to fluidize the solder just on the these contact pads, *not touching any other part of the circuit with the solder iron tip*. When the adjoining solder pad R518 also holds an electronic component, please remove it in the same way, too (**FAMP8**: R118/218/318/418).

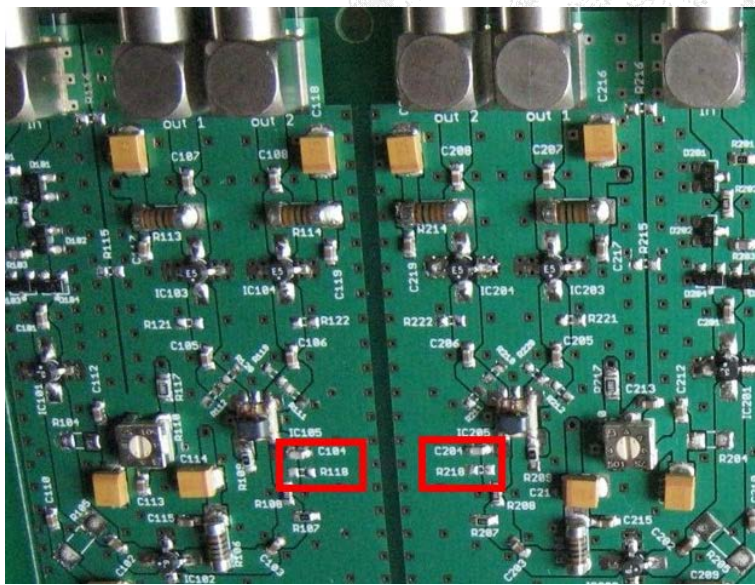
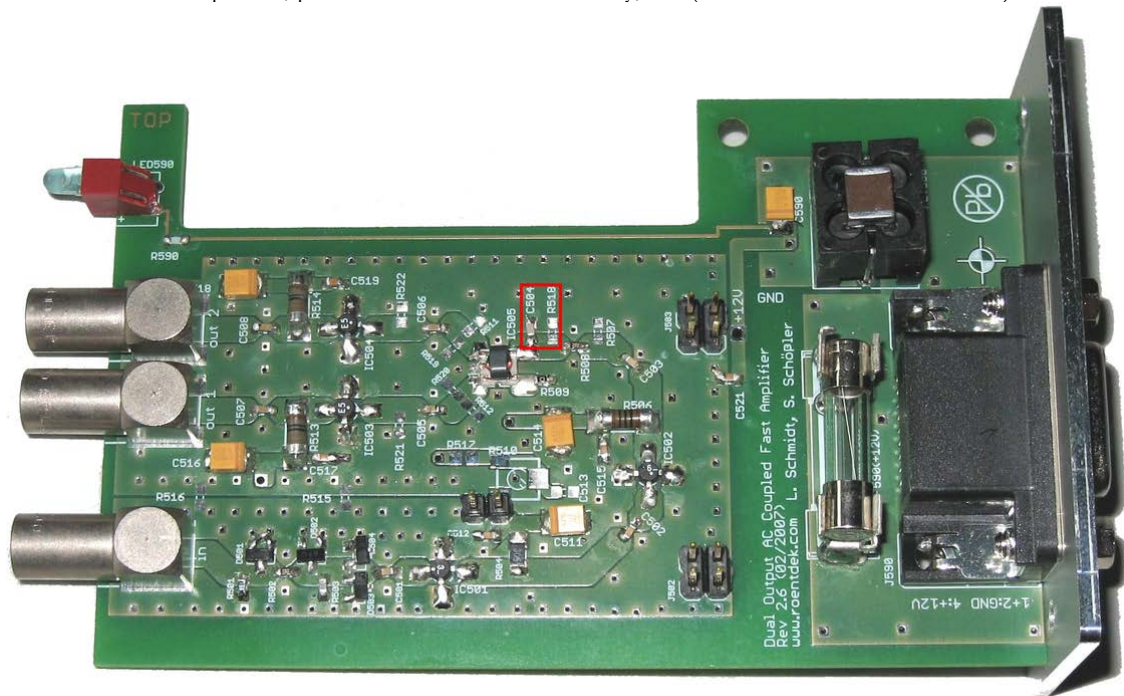


Figure 3.4a: Above: FAMP1+ circuit board (with piggyback gain adjustment board removed). The circuits to be removed are marked with a red box. Right picture: Detail of the FAMP8 circuit boards, red boxes mark the capacitors for two channels. Removing them increases the bandwidth of a certain channel to approximately 300 MHz.

3a.1.3 FAMP8c Amplifier

The **FAMP8c** amplifier contains modified internal boards similar to the versions used in the **FAMP3/6** family (see Chapter 3a.2). This allows adapting the **FAMP8c** for use with different delay-line anode types. In its standard setting its operation characteristics are very similar as of the **FAMP8/1+** used for helical wire anode and MCP signal amplification.

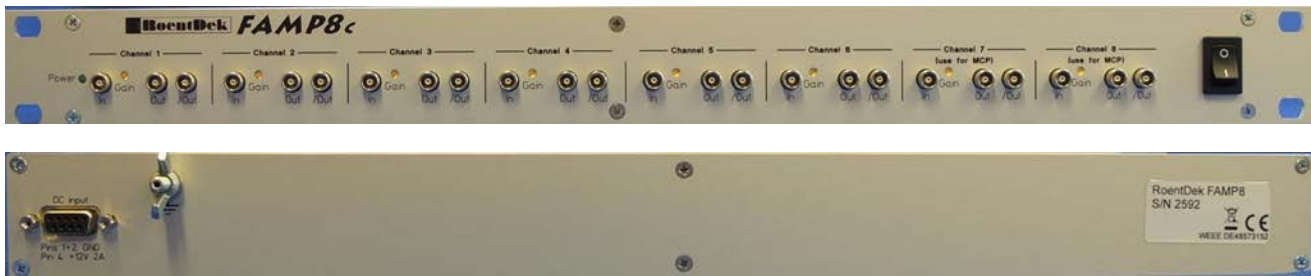


Figure 3.5a: Front and rear panel of FAMP8c module (mains power adapter not shown).

Similar to the **FAMP8** the **FAMP8c** 19" rack mount case (one height unit) hosts 8 individual bipolar amplifiers with a bandwidth of typically 80 MHz (channel 7 and 8: 120 MHz) via an AC-coupled input (50 Ω impedance, lemo00 connector) and both inverting/non-inverting outputs. The nominal amplification factor is about 50 and can be adjusted between 20 % and 180 % with potentiometers on the front panel. The maximum linear output signal height is approx. ± 1.5 V. Amplification of inverting and non-inverting output may differ within 10 %.

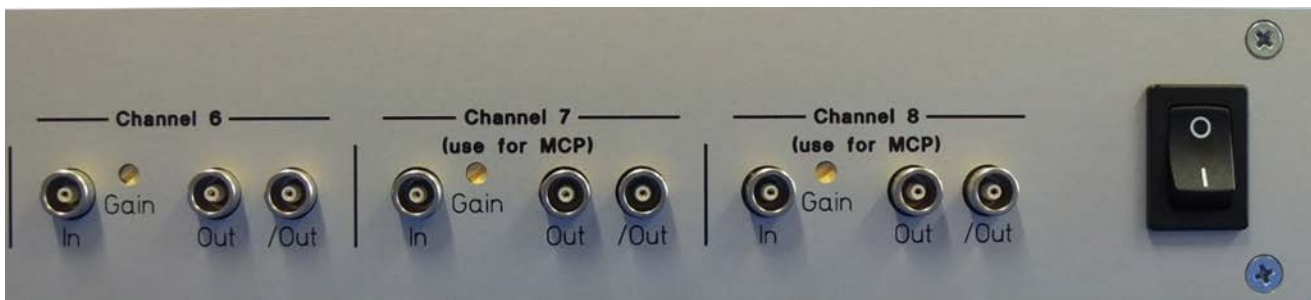


Figure 3.6a: Detail of the FAMP8c front panel showing with in-/output sockets and individual gain potentiometers. The bandwidth of channel 7 and 8 is increased compared to the other 6 channels (used for delay-line signals). If the bandwidth of individual channels differ from the default value this is indicated on the rear panel.

The unit has a power consumption of about 25 Watt (2 A at +12 V) and is equipped with an over-temperature protection. It comes with an external power supply for 100-250 V AC (50-60 Hz) mains power. The size is approximately 484 mm x 45 mm x 167 mm (width x height x depth, Insertion depth including power connector: 230 mm), with weight of 1400 g (without power adapter).

The **FAMP8c** is suited for signal amplification of all **RoentDek** detectors with **RoentDek FT12(16)TP** (or similar) signal decouplers in combination with a constant fraction discriminator (e.g. **RoentDek CFD8c**) and timing digitizer (e.g. **RoentDek TDC8HP**) or with a fast ADC system (e.g. **RoentDek fADC8**). In the version **BFAMP8c** (see Chapter 3a.3) it can also operate with the **RoentDek cTDC10**.

3a.2 The amplifiers FAMP3, (D)FAMP6(L), PreFAMP6

The **RoentDek (D)FAMP6** and **FAMP3** series are bipolar amplifier units (part of the **FEE5** front-end electronics assembly) for the amplification of high frequency pulse signals as obtained from micro-channel plate detectors, certain timing read-out anodes (e.g. delay-line) and various kinds of secondary electron amplifiers (photomultiplier, channeltron, etc.). They provide both inverting (“/OUT”) and non-inverting (“OUT”) outputs on which gain may differ within up to 10 %. The internal circuits of **FAMP3** and **FAMP6** are almost identical but although providing the same functions as the **FAMP1+/8*** units the internal boards can be more flexibly adopted/reconfigured to allow for different combinations of bandwidth, gain and impedance (usually 50 Ω) and also for differential amplification (version **DFAMP6** with 100 Ω differential input impedance). The **FAMP3b/FAMP6b** versions (especially designed for the amplification of LC-delay-line signals) have factory-fixed bandwidth / gain settings of 15 MHz / 300x. Changing the factory-set circuitry determining bandwidth and other parameters is possible but requires advanced soldering skills and is thus not recommended without consulting **RoentDek**.

The **PreFAMP6** units are fixed-gain “booster” amplifiers for low-gain demands or for further serial (bandwidth limited) gain increase.

* The **FAMP8c** also employs the more flexible circuit scheme of the **FAMP3/6** family.

3a.2.1 (D)FAMP6 Amplifier

The signal inputs of the 6 independent amplifier channels in the **(D)FAMP6** are found on the rear panel. While the **FAMP6** uses LEMO 00 series coax sockets for signals with $50\ \Omega$ input impedance to ground, the **DFAMP6** has 2x3 differential inputs ($100\ \Omega$ differential impedance) supplied via two CAT6 sockets, (see Figure 3.8a). The CAT6 internal cable numbers 1/2, 4/5 and 7/8 are used for these connections (numbers 3 and 6 not connected). The upper CAT6 cable (left side here) serves channels 1 to 3, the lower channels 4 to 6 (channel order defined in the signal source). For the **RoentDek** detector systems this corresponds to channel order x1-y1-z1 and x2-y2-z2 for the differential **FT12TPhex** decoupler, respectively x1-y1-MCPfront and x2-y2-MCPback from the **dFT12TP** for DLD.



Figure 3.7b:
DFAMP6 front panel with signal outputs and gain potentiometers

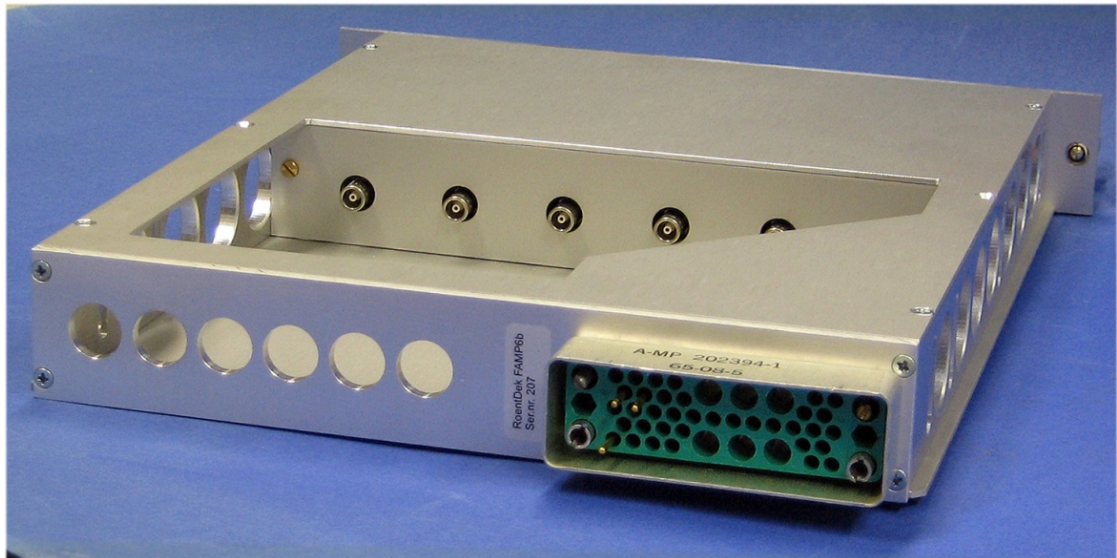


Figure 3.8a: Rear view of a FAMP6 with power connector to NIM bin and signal inputs.
Above: LEMO sockets, below: differential inputs via special CAT6 connector



The default bandwidth / max. gain setting of a **(D)FAMP6** amplifier is 80 MHz / 200x. Deviations from these factory-set values (if any) are noted on the back panel: Individual channels can have optional factory-set bandwidth / gain.

Potentiometers on the front panel allow reducing the set gain individually for each channel between 0 and 100 % (which may also alter bandwidth). The maximum linear output signal height is approximately $\pm 1.5\ \text{V}$, supplied via $50\ \Omega$ coax sockets. Amplification of inverting (/out) and non-inverting output may differ within 10 %.

When you need to replace the CAT6 cables supplied by **RoentDek**, please make sure to use CAT6 PiMF cables only (PiMF stands for Pairs in Metal Foil, ensuring that the three cable pairs used for signal transmission are individually shielded).

The **(D)FAMP6** is designed as 1/12 NIM cassette with (approx.) size 34 mm x 220 mm x 280 mm (width x height x depth) and 800 g weight, to be powered via a NIM bin (power requirements $\pm 6\ \text{V}$, 0.4 A). It can optionally be supplied with external

12 V mains adapter* connected to a 9-pin sub-D socket on the rear panel (this connector will then be factory-installed instead of the NIM bin power input).

3a.2.2 FAMP3(b) and FAMP6L(b) Amplifier

The signal inputs of the 3 (FAMP3) or 6 (FAMP6L) independent amplifier channels in the FAMP3/6L are found on the rear panel as LEMO 00 series coax sockets with 50 Ω input impedance to ground (see Figure 3.9a). The default bandwidth / max. gain setting of a FAMP3/6L amplifier is 200 MHz / 100x. Deviations from these factory-set values (if any) are noted on the back panel: Individual channels can have optional factory-set bandwidth / gain. Potentiometers on the rear panel allow reducing the set gain individually for each channel between 0 and 100 % (which may also alter bandwidth). The maximum linear output signal height is approximately ±1.5 V, supplied via 50 Ω coax sockets. Amplification of inverting (/out) and non-inverting output may differ within 10 %.

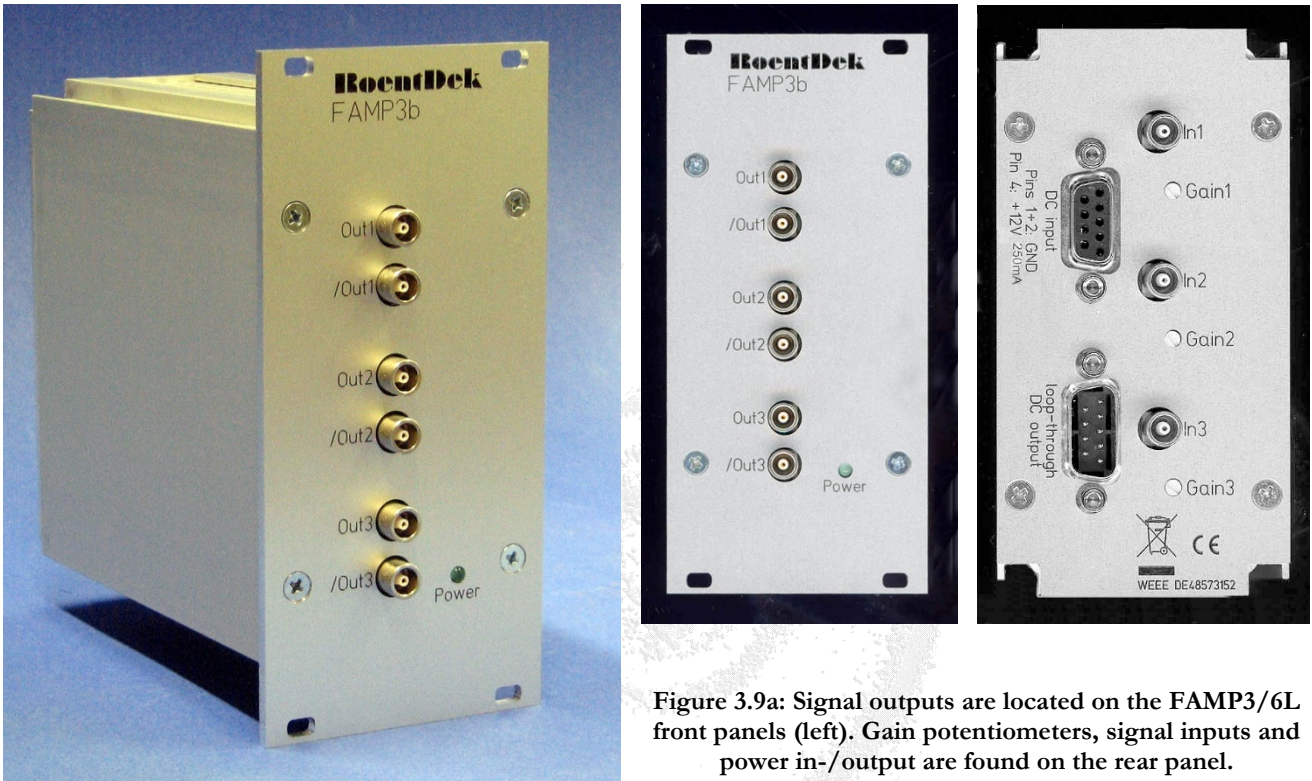
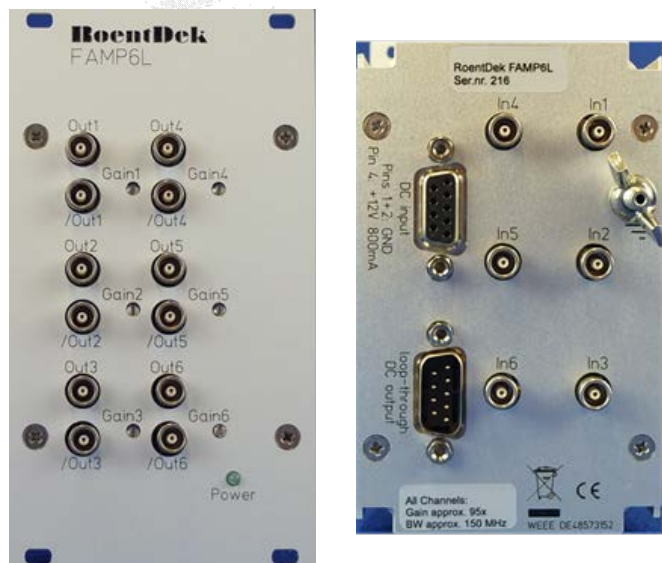


Figure 3.9a: Signal outputs are located on the FAMP3/6L front panels (left). Gain potentiometers, signal inputs and power in-/output are found on the rear panel.

The FAMP3 module is designed as a standard 3HU 19” case with (approx.) size 61 mm x 128 mm x 122 mm (width x height x depth) and 450 g weight (without power adapter). It comes with a mains power adapter* for 100-250 V AC. The power consumption is 0.4 A at +12 V. The power connection can be daisy-chained via 9-pin sub-D connection cables between several modules. When you order more than one FAMP3, you might receive only one power supply plus an adequate number of sub-D cables.

The FAMP6L version has 550 g weight and a slightly increased case width (71 mm) and power consumption of 0.8 A at +12 V.



* No mains power supply (neither from RoentDek units or others modules) should be placed near the FAMP modules or the input signal cables to minimize the risk of EM-noise pickup.

3a.2.3 PreFAMP6 Amplifier

The **PreFAMP6** units (see Figure 3.10a) are fixed-gain “booster” amplifiers for customer-specific demands of low-gain amplification or for overall gain increase when used in series with another amplifier. Additionally, a **PreFAMP6** may serve as an active bandwidth limiter device or impedance transformer. It is often used in combination with LC-delay-line anodes.

The **PreFAMP6** has only one (non-inverting) output per channel and the gain is factory-set to values between 2 and 6 for up to 6 individual channels.

The **PreFAMP6** comes as a stand-alone box with size 115 mm x 40 mm x 105 mm, weight 300 g. Some early versions need an external power input of ± 6 V (0.2 A) via front panel inputs, e.g. from a **RoentDek SPS1b** mains adapter. Later models only need +12 V with up to 0.3 A and come with an external mains power adapter for 100-250 V AC. Several of these newer modules can be daisy-chained via 9-pin sub-D connection cables.

It is to be noted that the **PreFAMP6** should not be used for input signals with maximum pulse heights below 100 mV (positive or negative polarity).



Figure 3.10a: Rear panel of PreFAMP6 (left) with signal inputs and DC power input via 9-pin sub-D connector or sockets for 2 mm pins (+12 V version provides a power output for daisy-chaining instead of the 2 mm pin sockets). Right: front panel of PreFAMP6 with signal outputs.

RoentDek offers modules with similar functions as the **PreFAMP6**: the **DCA8** and the **MIXA8/MIXA2** units. All allow signal amplification on 8 (**DCA8**, **MIXA8**), resp. 2 (**MIXA2**) channels with low gain and even signal damping (nominal gain < 1). Additionally, the **DCA8** can add a DC level on the output socket, while the **MIXA8/MIXA2** units can mix several input signals into a superimposed output signal.

For further information about these modules, please refer to the description sheets of the respective units.

3a.2.4 Modifying set values of bandwidth, gain and impedance

The default values of bandwidth, impedance and (max.) gain are factory-set for certain applications. While the amplification of signals from standard **DLD** or **Hex** helical-wire delay-line anodes requires very similar settings it is necessary to reduce bandwidth significantly for other types of signals (e.g. as obtained from an LC delay-line) and it may be necessary to increase gain to compensate for the lower pulse height (i.e. whenever a certain amount of primary charge input from a detector is stretched into a broader signal). Also, operating larger helical wire delay-line anode types can benefit from decreased bandwidth under certain experimental conditions.

RoentDek strongly recommends considering modifying bandwidth only when absolutely necessary for your application. However, it is to note that *changing bandwidth does not necessarily improve the detector performance* but can instead *increase the susceptibility for noise pickup, ringing, inter-channel cross talk and non-linear time response*. The factory-set bandwidth limitation ensures specific *signal shaping* that is *crucial for optimal* performance of the **RoentDek** detectors, especially for *imaging results* with delay-line anodes.

Changing bandwidth requires *special soldering skills/tools* and adequate replacement circuits. *Lead-free solder and clean solder tools must be used*. Please contact **RoentDek** before modifying the bandwidth. Modifications should ideally be done by **RoentDek** staff. If you feel apt to do that by yourself please request the service manual.

Warranty may be lost in case of unprofessional modification of the internal circuits.

3a.3 The bipolar-output amplifiers BFAMP3, BFAMP1 and BFAMP8c

For certain digital read-out modules such as fast ADCs (e.g. **RoentDek fADC**) it can be of advantage or even mandatory (for **RoentDek cTDC**) to re-shape the output signal from a standard **FAMP** module into a bipolar signal trace. Forming a bipolar output shape from an (unipolar) input signal is accomplished by summing up the inverted and non-inverted amplified signals after introducing a specific delay between the two components. In case of the **RoentDek BFAMP** units this delay is determined by the length of an external cable. If no delay cable is set, the **BFAMP** circuit operates like a standard **FAMP**.

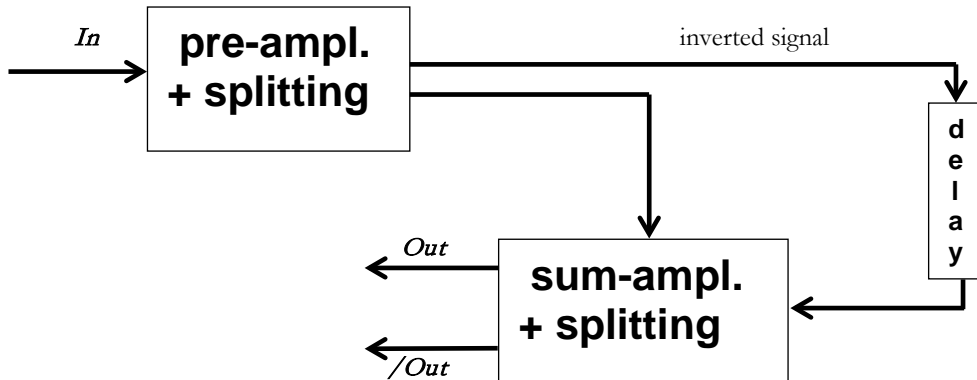


Figure 3.11a: Sketch of signal shaping by a BFAMP circuit

The signal shaping as sketched in Figure 3.11a follows a similar scheme as in standard Constant-Fraction Discriminator units. However, signals that enter the **BFAMP** circuit are first amplified (with adjustable gain, typically between 20x and 200x) before being split into signals with different polarity. Both partial signals nominally have the same amplitude, thus the so-called fraction ratio is set to 1. The external delay corresponds to the *CFD delay* and acts on the inverted signal. The partial signals are then superimposed by a sum-amplifier stage towards a bipolar-shaped signal trace, which is further amplified by a factor of about 10. The *CFD delay* must be well chosen and is usually on the order of the input signal's FWHM and is introduced by an external cable in the path of the inverted (partial) signal before the sum-amplifier stage.

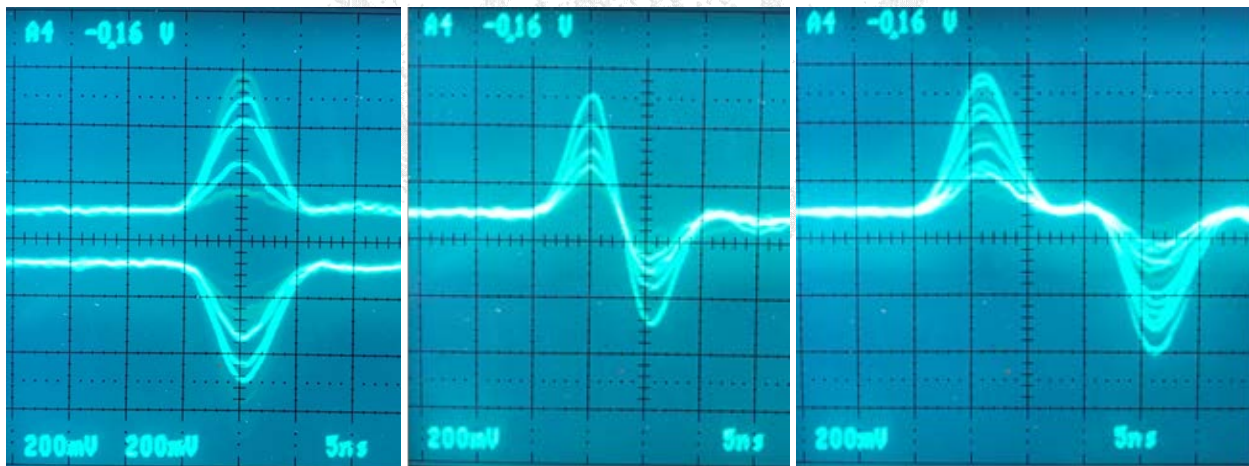


Figure 3.12a: Typical output signal shapes of a BFAMP circuit for input signals of different pulse heights but constant width (FWHM about 6 ns). Left picture: signal traces from the *Out* and */Out* sockets without *CFD delay* cable (i.e. standard **FAMP** functionality). Middle picture : signal output with delay-cable set on rear panel (only inverted output displayed). Right picture: trace for a too-long delay-cable so that the signals do not overlap for forming a suitable bipolar shape. All traces have been triggered by an external timing signal reference.

Signals entering the input of the **BFAMP** at the same time will have a zero-crossing time independently of their pulse height if the *CFD delay* is properly chosen with respect to the input signal, i.e. so that a continuous bipolar output signal shape as in Figure 3.12a, middle picture is achieved. Therefore, the cross-over instant suits as a precise time marker for a signal.

The bipolar output signal shape can be characterized by the signal rise time (RT) and the time interval d_{t0} between the peak maximum and the zero-crossing of the signal trace (see Figure 3.14a). While the rise time is mainly determined by the input

signal's rise time (and the chosen bandwidth of the amplification circuit), dt_0 also depends on the chosen *CFD delay*. It is to note that dt_0 ideally remains constant for all input signal amplitudes. A remaining jitter of dt_0 from noise influence will directly determine the achievable temporal resolution.

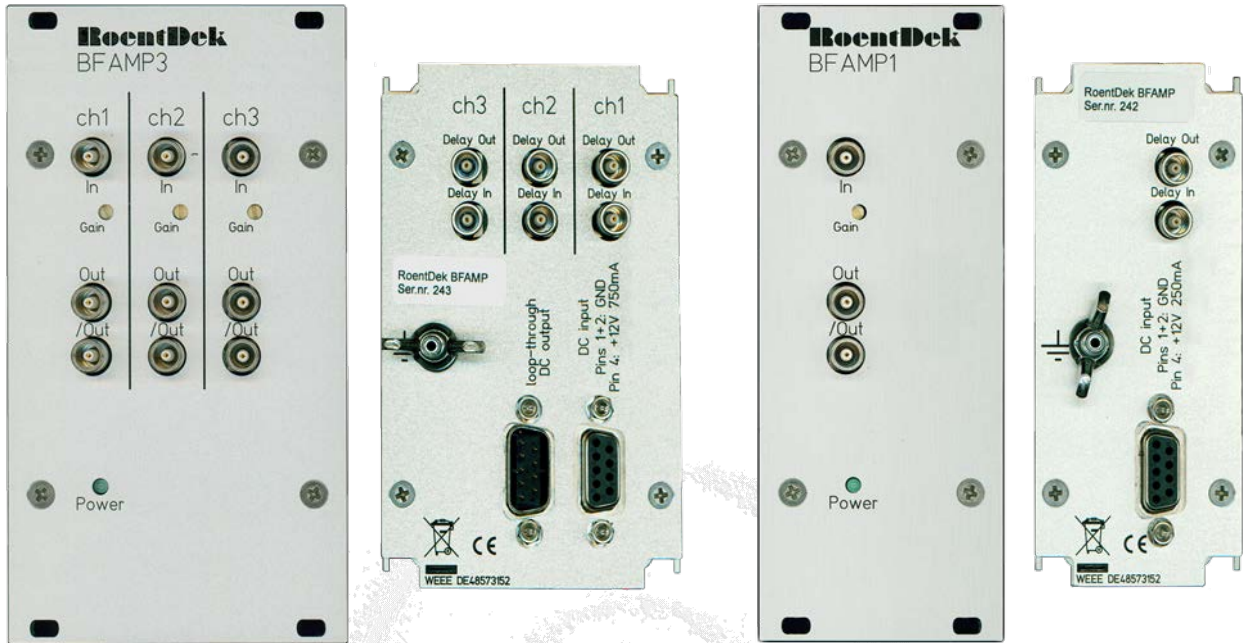


Figure 3.13a: front and back panel in-/outputs and controls of BFAMP units. The Delay In/Out sockets of the BFAMP8c are likewise located on the module's rear-panel (front panel appearance as of FAMP8c).

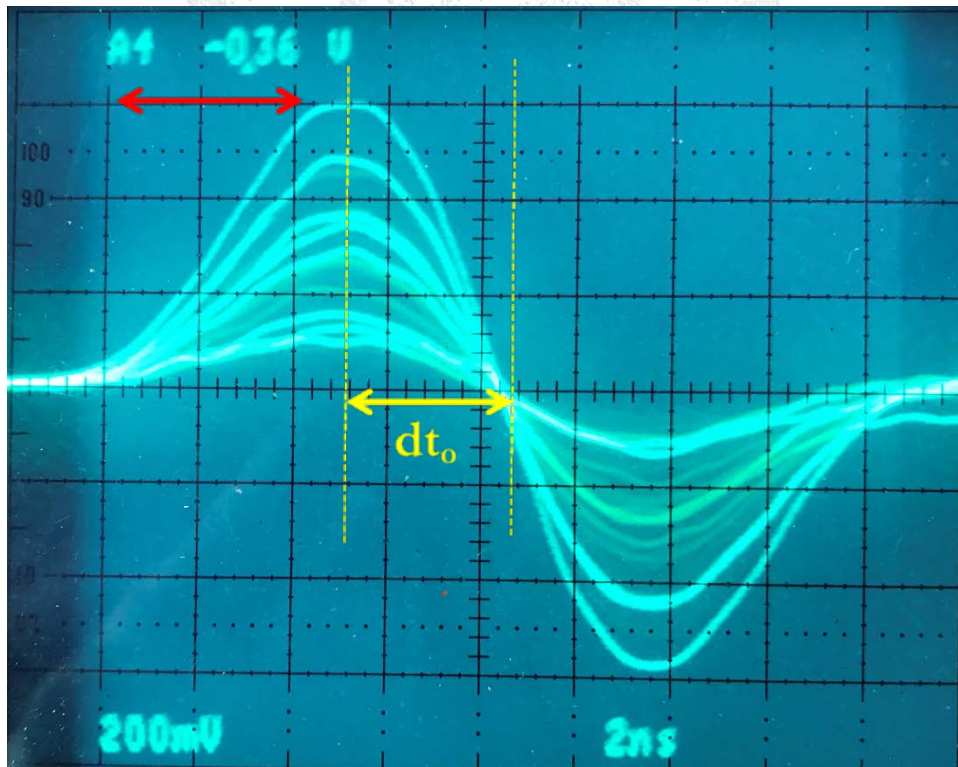


Figure 3.14a: Signal trace with *CFD delay* = 6 ns \approx FWHM ($RT_{10-90} = 4 \text{ ns}$), dt_0 is 3.2 ns (for all pulse heights).

Optimal resolution requires a *CFD delay* well adapted to the signal shape. For near-Gaussian (i.e. symmetric) pulse shapes, *CFD delay* = FWHM is an adequate choice (ideally: width between inflection points on the signal curve). If the signal shape is very asymmetric the signal rise time (*Rt*) may be used to determine a proper value for *CFD delay*:

$$CFD\ delay = FWHM \approx 1.5 \cdot Rt_{(10\% - 90\%)} \approx 3 \cdot Rt_{(25\% - 75\%)} \quad \text{Equation 3.1a}$$

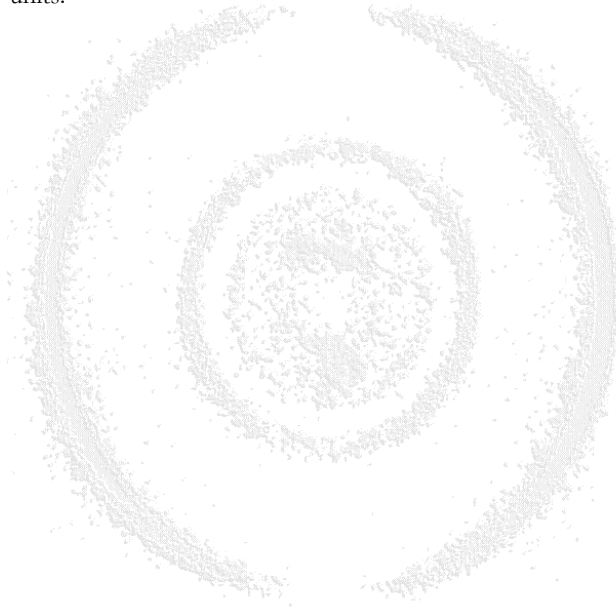
For determining signal rise time or FWHM it is important to refer to the (unipolar) output signals observed on the *Out* or */Out* sockets before a delay cable is connected on the rear panel of a BFAMP unit because the amplifier bandwidth may lead to a significant difference between the raw input and the amplified output signal widths.

For high-rate operation, it is of advantage to set a *CFD delay* so that the integrals under the positive and negative portions of the output signal trace are of equal amount.

Since one input of the internal *sum-ampl. + splitting stage* (see Figure 3.11a) can be separately addressed via the *Delay In* socket one can also use the **BFAMP** circuit for mixing virtually any (AC) signal onto the (then pre-amplified) signal that entered the *In* socket of a module. It is important to consider that the mixed signal will be further amplified by a factor of about 10.

Thus, the **BFAMP** circuit can be used for similar task as the **RoentDek MIXA** units, for example to route different signal output lines to a single input of a post-processing unit, e.g. a **RoentDek fADC**.

A **BFAMP** unit can always be operated like a standard **FAMP**: If no delay cable is placed, the output response of a **BFAMP** corresponds to those of **FAMP** units.



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FIGURE 3.1A: FAMP8 MODULE (MAINS POWER ADAPTER NOT SHOWN). THE HOLES IN THE TOP LID HERE ALLOW ACCESS TO THE ON-BOARD POTENTIOMETERS FOR AMPLIFICATION GAIN ADJUSTMENT OF CHANNELS 1 TO 6 (ONLY OLDER VERSION). 5

FIGURE 3.2A: DETAIL OF THE FAMP8 FRONT PANEL WITH IN-/OUTPUT SOCKETS FOR ONE CHANNEL AND GAIN POTENTIOMETER. 6

FIGURE 3.3A: FAMP1+, LEFT PICTURE WITH GAIN POTENTIOMETER ON TOP LID, RIGHT PICTURE: NEWER MODEL WITH GAIN POTENTIOMETER ON FRONT PANEL. THE FAMP1+ MODULE IS ALSO AVAILABLE AS 3HU UNIT FOR RACK MOUNTING (NOT SHOWN). 6

FIGURE 3.4A: ABOVE: FAMP1+ CIRCUIT BOARD (WITH PIGGYBACK GAIN ADJUSTMENT BOARD REMOVED). THE CIRCUITS TO BE REMOVED ARE MARKED WITH A RED BOX. RIGHT PICTURE: DETAIL OF THE FAMP8 CIRCUIT BOARDS, RED BOXES MARK THE CAPACITORS FOR TWO CHANNELS. REMOVING THEM INCREASES THE BANDWIDTH OF A CERTAIN CHANNEL TO APPROXIMATELY 300 MHz. 7

FIGURE 3.5A: FRONT AND REAR PANEL OF FAMP8C MODULE (MAINS POWER ADAPTER NOT SHOWN). 8

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FIGURE 3.7B: DFAMP6 FRONT PANEL WITH SIGNAL OUTPUTS AND GAIN POTENTIOMETERS. 9

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FIGURE 3.10A: REAR PANEL OF PreFAMP6 (LEFT) WITH SIGNAL INPUTS AND DC POWER INPUT VIA 9-PIN SUB-D CONNECTOR OR SOCKETS FOR 2 MM PINS (+12 V VERSION PROVIDES A POWER OUTPUT FOR DAISY-CHAINING INSTEAD OF THE 2 MM PIN SOCKETS). RIGHT: FRONT PANEL OF PreFAMP6 WITH SIGNAL OUTPUTS. 11

FIGURE 3.11A: SKETCH OF SIGNAL SHAPING BY A BFAMP CIRCUIT. 12

FIGURE 3.12A: TYPICAL OUTPUT SIGNAL SHAPES OF A BFAMP CIRCUIT FOR INPUT SIGNALS OF DIFFERENT PULSE HEIGHTS BUT CONSTANT WIDTH (FWHM ABOUT 6 NS). LEFT PICTURE: SIGNAL TRACES FROM THE *OUT* AND */OUT* SOCKETS WITHOUT *CFD DELAY* CABLE (I.E. STANDARD FAMP FUNCTIONALITY). MIDDLE PICTURE : SIGNAL OUTPUT WITH DELAY-CABLE SET ON REAR PANEL (ONLY INVERTED OUTPUT DISPLAYED). RIGHT PICTURE: TRACE FOR A TOO-LONG DELAY-CABLE SO THAT THE SIGNALS DO NOT OVERLAP FOR FORMING A SUITABLE BIPOLAR SHAPE. ALL TRACES HAVE BEEN TRIGGERED BY AN EXTERNAL TIMING SIGNAL REFERENCE. 12

FIGURE 3.13A: FRONT AND BACK PANEL IN-/OUTPUTS AND CONTROLS OF BFAMP UNITS. THE DELAY IN/OUT SOCKETS OF THE BFAMP8C ARE LIKEWISE LOCATED ON THE MODULE'S REAR-PANEL (FRONT PANEL APPEARANCE AS OF FAMP8C). 13

FIGURE 3.14A: SIGNAL TRACE WITH *CFD DELAY* = 6 NS \approx FWHM (RT_{10-90} = 4 NS), DT_0 IS 3.2 NS (FOR ALL PULSE HEIGHTS). 13

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