Matching the Preamplifier to the Detector and the Application

The primary function of a preamplifier is to extract the signal from the detector without significantly degrading the intrinsic signal-to-noise ratio. Therefore, the preamplifier is located as close as possible to the detector, and the input circuits are designed to match the characteristics of the detector. Different pulse processing techniques are typically employed, depending on whether the arrival time or the amplitude (energy) of the detected event must be measured. Pulse shaping for either application is normally implemented in a subsequent module. This module can be located at some distance from the preamplifier, provided that the signal fidelity is not degraded due to the length of the interconnecting coaxial cable.

Several types of detectors produce moderately large signals at their outputs, and this relaxes the restrictions on the noise contribution from the preamplifier. Detectors that typically fall in this category are: photodiodes operating with intense light pulses, photomultiplier tubes (PMT), scintillation detectors (scintillator mounted on a PMT), microchannel plate PMTs, microchannel plates, channeltrons, and electron multipliers. For such detectors, a wideband amplifier with a low input impedance can be used directly at the detector output to generate short, fast-rising pulses for timing or counting purposes. For pulse-amplitude (or energy) spectroscopy, a relatively inexpensive preamplifier, such as the Model 113 or the Model 142IH, can be used to integrate the charge in the pulse at the detector output.

Detectors with much better resolution are frequently used for energy spectroscopy with x-rays, gamma rays, and charged particles. Typical detectors in this category are: Si(Li) (planar), germanium (coaxial, LO-AX™, and planar), silicon charged-particle detectors, and gas proportional counters. Because such detectors produce very small output signals, it is essential that the input stage of the preamplifier contribute little noise. The requirement for low noise and stable sensitivity with these detectors is met by using a charge-sensitive preamplifier with an FET (Field-Effect Transistor) input stage. For silicon charged-particle detectors and proportional counters the entire preamplifier usually is operated at room temperature. However, the excellent resolution of the cooled germanium and Si(Li) detectors necessitates lowering the temperature of the FET input stage of the preamplifier to reduce the noise. Operation at a temperature near 12° K is accomplished by mounting the FET near the detector inside the cryostat. Specifications for these cooled preamplifiers are incorporated with the relevant detector in the ORTEC Detector Catalog. The room-temperature preamplifiers are described on the next few pages. The signal at the output of the charge-sensitive preamplifier can be used for either timing or energy spectroscopy.

ORTEC manufactures a preamplifier to fit your detector, your application, and your budget. The applications information and selection guides will help you to choose the optimum preamplifier for your task.

Preamplifier Types

Three basic types of preamplifiers are available: the current-sensitive preamplifier, the parasitic-capacitance preamplifier, and the charge-sensitive preamplifier. The following paragraphs describe their functions and primary performance characteristics.

Current-Sensitive Preamplifiers

Several detector types, such as photomultiplier tubes and microchannel plates, generate a moderately large and fast-rising output signal through a high output impedance. Pulse processing for timing or counting with these detectors can be rather simple. A properly-terminated 50-Ω coaxial cable is attached to the detector output, so that the current pulse from the detector develops the desired voltage pulse across the 50-Ω load presented by the cable. For scintillators mounted on 14-stage photomultiplier tubes, this voltage signal is usually large enough to drive the input of a fast discriminator without further amplification. For single-photon counting, 10-stage photomultiplier tubes, or microchannel plate PMTs, additional amplification is needed between the detector and the discriminator, and this is the function of the current-sensitive preamplifier.

The 50-Ω input impedance of the current-sensitive preamplifier provides proper termination of the 50-Ω coaxial cable, and converts the current pulse from the detector to a voltage pulse. If the rise time of the preamplifier is negligible compared to the detector rise time, and the voltage gain of the preamplifier is A, the amplitude of the voltage pulse at the preamplifier output will be

\[ V_{out} = 50 \times I_n \times A \]  

(1)

where \( I_n \) is the amplitude of the current pulse from the detector. For counting applications this signal can be fed to a fast discriminator, whose output is recorded by a counter/timer.

For timing applications the dominant limitation on timing resolution with photomultiplier tubes and microchannel plates is fluctuation in the transit times of the electrons as they cascade through the detector. This causes a jitter in the arrival time of the pulse at the detector output. However, if the detector signals are small enough to require a current-sensitive preamplifier, the effect of preamplifier input noise on time resolution must also be considered.
The noise added to the signal by the preamplifier causes an uncertainty or jitter in the time at which the pulse crosses the threshold of the timing discriminator. The result is a degradation of the time resolution. Therefore, it is important to choose a current-sensitive preamplifier whose rise time is similar to the rise time of the pulse at the detector output. A preamplifier rise time that is much faster than the detector rise time does not improve the signal rise time. But, it does contribute extra noise, because of the unnecessarily wide bandwidth. This excess noise will increase the timing jitter. Choosing a preamplifier rise time that is much slower than the detector rise time reduces the preamplifier noise contribution, but not enough to overcome the degradation in pulse rise time and amplitude. Consequently, the timing jitter becomes worse.

Although the optimum choice depends on the rise time and amplitude of the detector signal, as well as the characteristics of the preamplifier input stage, a good guideline is to choose a preamplifier rise time that is within a factor of 2 of the detector rise time (faster or slower). Rise times for photomultiplier tubes range from 1.5 to 10 ns, making the Models VT120, 9301, and 9305 Preamplifiers appropriate for consideration. The Model 9306 1-GHz Preamplifier is the optimum choice for timing with the 150-ns rise times encountered with microchannel plate PMTs.

Most fast preamplifiers with gains in excess of 10 must employ ac-coupling between internal amplifying stages to achieve fast rise times and to eliminate dc drift with temperature. This is an excellent solution if the average spacing between pulses is greater than 100 times the individual pulse width. But, when the average spacing between pulses becomes comparable to the pulse width, the ac-coupling causes the baseline between pulses to shift so that the preamplifier output signal circumscribes as much area above ground potential as it does below ground. This effect distorts the amplitude measurement in subsequent modules. The Model 9305 Preamplifier offers a solution to this problem in cases where lower gain (A=10) and a slightly slower rise time (3 ns) is acceptable. The Model 9305 is dc-coupled and exhibits excellent dc stability. By operating a photomultiplier tube with the cathode at high voltage, the anode can be dc-coupled to the input of the Model 9305 Preamplifier. This scheme eliminates the baseline shift at high counting rates, and permits operation at much higher counting rates.

Most current-sensitive preamplifiers designed for timing applications have ac-coupled time constants in the range of a few hundred nanoseconds. The model 9326 overcomes that limitation by offering a low-frequency roll-off at an exceptionally low 10 kHz.

**Parasitic-Capacitance Preamplifiers**

Photomultiplier tubes, electron multipliers, microchannel plates, and microchannel plate PMTs produce moderately large output signals with very fast rise times. Therefore, the most cost-effective preamplifier for pulse-amplitude measurements or energy spectroscopy with these detectors is the parasitic-capacitance preamplifier illustrated in Fig. 2.

Parasitic-capacitance preamplifiers have a high input impedance (~5 MΩ). Hence, the current pulse generated by the detector is integrated on the combined parasitic capacitance present at the detector output and the preamplifier input. This combined capacitance is typically 10 to 50 pF. The resulting signal is a voltage pulse having an amplitude proportional to the total charge in the detector pulse, and a rise time equal to the duration of the detector current pulse. A resistor connected in parallel with the input capacitance causes an exponential decay of the pulse with a time constant ~50 μs. An amplifier having a high input impedance and unity gain is included as a buffer to drive the low impedance of a coaxial cable at the output. The 93-Ω resistor in series with the output absorbs reflected pulses in long cables by terminating the cable in its characteristic impedance.

Parasitic-capacitance preamplifiers are not used with semi-conductor detectors because the gain of this type of preamplifier is sensitive to small changes in the parasitic capacitance. For partially-depleted semiconductor detectors the detector capacitance varies with the bias voltage applied to the detector diode. In addition, small movements of the interconnecting cable can change the input.
Preamplifier Introduction

capacitance by a few tenths of a pF. The gain changes caused by these effects are significant for semiconductor detectors, which have energy resolutions better than 1%. However, parasitic-capacitance preamplifiers, such as the ORTEC Model 113, provide more than adequate performance with photomultiplier tubes, microchannel plate PMTs, or scintillation detectors, and are highly recommended for those applications.

**Charge-Sensitive Preamplifiers**

These preamplifiers are preferred for most energy spectroscopy applications. The signal from a semiconductor detector or ion chamber is a quantity of charge delivered as a current pulse lasting from $10^{-4}$ to $10^{-2}$ s, depending on the type of detector and its size. For most applications the parameters of interest are the quantity of charge and/or the time of occurrence or an event. A charge-sensitive preamplifier (Fig. 3) can deliver either or both. Because it integrates the charge on the feedback capacitor, its gain is not sensitive to a change in detector capacitance, and in the ideal case, the rise time of the output pulse is equal to the detector current pulse width.

The output voltage from the preamplifier has an amplitude $V_o$, and a decay time constant $\tau_f$, given respectively by

$$V_o = \frac{Q_o}{C_f} \quad \text{and} \quad \tau_f = R_fC_f$$  \hspace{1cm} (2)

where $Q_o$ is the charge released by the detector, $C_f$ is the feedback capacitor (0.1 to 5 pF), and $R_f$ is the feedback resistor. $R_f$ is a noise source and in direct-coupled systems, is made as large as possible consistent with the signal energy-rate product and the detector leakage current. The preamplifier package is kept small to permit mounting it as close as practical to the detector, thus reducing input capacitance caused by cabling and decreasing microphonic noise, ground loops, and radio frequency pickup, all of which are sources of noise for the charge-sensitive preamplifier.

In the selection chart, sensitivity is generally expressed in mV per MeV of energy deposited in a given detector material. The charge released by the detector is a function of the photon or particle energy and the detector material, and is given by

$$Q_o = \frac{E \cdot e \times 10^6}{\varepsilon}$$  \hspace{1cm} (3)

where $E$ is the energy in MeV of the incident radiation, $e$ is the charge of an electron ($1.6 \times 10^{-19}$ coulomb), $10^6$ converts MeV to eV, and $\varepsilon$ is the amount of energy required to produce an electron-hole pair in the detector. Approximate values for $\varepsilon$ for various detectors are given in Table 1. For the special case of a proportional counter, the right hand side of Equation (3) must be multiplied by the gas gain of the proportional counter.

From Eqs. (2) and (3) the output voltage produced by a charge-sensitive preamplifier is

$$V_o = \frac{E(1.6 \times 10^{-19})}{C_f\varepsilon}$$  \hspace{1cm} (4)

Therefore, the preamplifier gain can be expressed as

$$\frac{V_o}{E} = \frac{e(10^6)}{C_f\varepsilon}$$  \hspace{1cm} (5)

The sensitivity of a preamplifier with $C_f = 1 \times 10^{-12}$ F connected to a room-temperature silicon detector is

$$\frac{V_o}{E} = \frac{(1.6 \times 10^{-19})(10^6)}{(1 \times 10^{-12})(3.62)} = 44 \text{ mV/MeV}$$  \hspace{1cm} (6)

---

**Table 1. Values of $\varepsilon$ for Various Detectors.**

<table>
<thead>
<tr>
<th>Detector</th>
<th>$\varepsilon$ (eV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silicon</td>
<td>3.62 (300° K)* to 3.71 (77° K)</td>
</tr>
<tr>
<td>Germanium</td>
<td>2.96 (77° K)</td>
</tr>
<tr>
<td>Proportional Counters</td>
<td></td>
</tr>
<tr>
<td>Argon</td>
<td>26.4</td>
</tr>
<tr>
<td>Methane</td>
<td>29.2</td>
</tr>
</tbody>
</table>

*Values in parentheses are temperatures at which the energy values were determined.
The input of the preamplifier appears as a large capacitor to the detector because the effect of the feedback capacitor at the input is magnified by the open loop gain of the charge loop. This input capacitance must be much greater than the other sources of capacitance connected to the preamplifier input (such as the detector or input cabling) in order for the preamplifier sensitivity to be unaffected by external capacitance changes. Since $C_r$ is generally $\sim 1 \times 10^{-12}$ F, the preamplifier open loop gain must be very large, usually greater than 10,000. The stability of the preamplifier sensitivity is dependent on the stability of $C_r$ (the feedback capacitor), and the preamplifier open loop gain. $C_r$ is selected for good temperature stability, and the open loop gain is made very large so that small changes in it can be neglected. Preamplifier sensitivity variations can contribute to the error in measuring the energy of the detected radiation.

Noise in charge-sensitive preamplifiers is generally controlled by four components: the input field effect transistor (FET), the total capacitance at the input ($C_r$, the detector capacitance, etc.), the resistance connected to the input, and input leakage currents from the detector and FET. The FET is selected for low-noise performance, and in some applications it is cooled to near liquid-nitrogen temperature to improve its performance. In cooled-FET applications the detector and preamplifier are generally built as an integral assembly. With room-temperature preamplifiers, the user controls the major sources of input capacitance in most applications, because the preamplifier is designed with minimum internal circuit capacitance. These sources are from the detector selected for an experiment and from the cabling between the preamplifier and the detector. Figure 4 is a graph showing the noise versus external capacitance for a typical preamplifier.

The noise of a charge-sensitive preamplifier can be measured by the system shown in Fig. 5. Charge $Q$, equivalent to the known energy, $E$, must be injected into the preamplifier, and the amplitude of the pulse $V_p$ resulting from this charge must be measured at the output of the filter amplifier to determine the system gain $V_p/E$. The charge can be injected by a detector and radiation source or a step pulse generator connected to the preamplifier input through a capacitor, sometimes referred to as a charge terminator. The preamplifier noise can be determined by measuring the root-mean-square (rms) noise voltage $V_{\text{rms}}$ at the output of the filter amplifier in the absence of any pulses, and using the following equation:

$$FWMH \text{ noise} = 2.35 \frac{E}{V_p} V_{\text{rms}} \quad (7)$$

Charge-sensitive-preamplifier noise performance is generally specified as the full width at half maximum (FWHM) of the energy line generated in the spectrum by a test pulser injecting charge into the preamplifier input. This value is normally given in keV. The parameter $V_{\text{rms}}$ must be multiplied by 2.35 to convert it to a FWHM specification.

The rise time of the voltage pulse $V_o$ at the output of the charge-sensitive preamplifier, in the ideal case, is equal to the charge collection time of the detector. When detectors with very fast collection times or large capacitances are used, the preamplifier itself may limit the rise time of $V_o$. If a time reference mark is being determined from $V_o$, it is desirable that the rise time $t_r$ of $V_o$ be as short as possible. For silicon detectors, the time resolution of the timing system following charge-sensitive preamplifiers is generally limited by the ratio of the FWHM preamplifier output noise $e_{\text{no}}$ to the slope $dV_o/dt$ of $V_o$ at the timing threshold:

$$\text{timing resolution (FWHM)} = e_{\text{no}}/(dV_o/dt) \quad (8)$$

A plot of a charge-sensitive-preamplifier output rise time versus detector capacitance is shown in Fig. 6. It is desirable to keep the external capacitance at a minimum to obtain the best timing resolution, as well as the best energy resolution.

To estimate the maximum counting rate $r_{\text{max}}$ that can be accommodated by a charge-sensitive preamplifier at a particular energy, it is
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necessary to identify the type of preamplifier being considered (see IEEE Standard 301-1988). With charged-particle detectors, the signal is normally extracted from the same detector electrode that accepts the bias voltage, and the preamplifier input is ac-coupled to the detector. The maximum counting rate tolerated by ac-coupled preamplifiers \( r_{\text{max,ac}} \) is controlled by the signal fluctuations and the maximum voltage \( V_m \) allowed at the charge loop output:

\[
r_{\text{max,ac}} = \frac{1.2 \sqrt{2} v \sqrt{C_r} \times 10^{13}}{E/R_t}
\]

(9)

The units are: \( r_{\text{max,ac}} \) in s\(^{-1}\), \( V_m \) in volts, \( e \) in eV, \( E \) in MeV, \( C_r \) in farads, and \( R_t \) in ohms. If the "energy-squared count-rate product" (i.e., \( E^{\text{CRP}} = E r_{\text{max,ac}} \)) is listed for the ac-coupled preamplifier, the maximum counting rate tolerated at the energy \( E \) can be calculated by dividing the \( E^{\text{CRP}} \) value by \( E^2 \).

The charge-sensitive preamplifiers used with germanium gamma-ray detectors and Si(Li) x-ray detectors are normally dc-coupled to the detector. For dc-coupled preamplifiers, the maximum counting rate accommodated at the energy \( E \) is controlled by \( R_t \) and \( V_m \).

\[
r_{\text{max, dc}} = \frac{\sqrt{2} \sqrt{C_r} \times 6.25 \times 10^{12}}{ER_t}
\]

(10)

If the "energy count-rate product" (i.e., \( E^{\text{CRP}} = E r_{\text{max,dc}} \)) is specified for the dc-coupled preamplifier, the maximum counting rate tolerated at the energy \( E \) can be calculated by dividing the \( E^{\text{CRP}} \) value by \( E \).

With pulsed-reset preamplifiers, the maximum counting rate limit for the preamplifier is the counting rate at which the percent dead time caused by the resetting becomes intolerable. The percent dead time resulting from preamplifier resetting is computed from

\[
\text{Percent Reset Dead Time} = 100 \times r \times T_{\text{reset}}/E_{\text{reset}}
\]

(11)

where \( r \) is the counting rate of the events of energy \( E \), \( E_{\text{reset}} \) is the total energy accepted between resets, and \( T_{\text{reset}} \) is the dead time caused by each reset. A rough approximation for \( T_{\text{reset}} \) can be obtained by adding the preamplifier reset time to the amplifier overload recovery time. Typically, amplifier overload recovery from the large reset pulse is the major contribution to the reset dead time.

Creating a Differential Output to Cancel Environmental Noise

When the coaxial cable connecting the preamplifier output to the shaping amplifier input is long and the cable runs through an electrically noisy environment, it is advantageous to employ differential signal transmission. Several amplifiers (Models 450, 671, 672, 973, and 973U) offer differential inputs for this purpose. A few preamplifiers include differential outputs to accommodate this function. If the preamplifier does not provide differential outputs, the box depicted in Figure 7 can be used to create a differential output.

All the components shown in Figure 7 are mounted in a small metal box located close to the preamplifier. Care must be exercised to ensure low-impedance grounds. The input on the left side of the box is connected to the normal preamplifier signal output with a coaxial cable that is as short as possible. This short cable must provide a low impedance path from the preamplifier ground to the metal box. The center conductor of this short cable transmits the normal preamplifier output signal through the box to the normal input of the shaping amplifier. The 93-\( \Omega \) resistor in the box is used to transmit the preamplifier ground signal to the differential reference input of the amplifier. Both the "normal" and the "differential reference" cables are RG-62A/U, 93-\( \Omega \) coaxial cables. Thus, the 93-\( \Omega \) resistor in the box provides reverse termination of the differential reference cable. This termination matches the 93-\( \Omega \) reverse termination included inside the preamplifier for the normal output signal.

To ensure that both cables are affected in the same way by electrical interference, the two cables are twisted together in a spiral as they are routed to the amplifier. When connected to the amplifier inputs, the normal signal includes the desired preamplifier signal plus
any interfering noise from ground loops or the environment. The differential reference signal includes only the interfering noise. Hence, when the amplifier subtracts the differential reference from the normal signal, the interfering noise is removed from the signal. Amplifiers with differential inputs usually incorporate a differential gain balancing adjustment to allow matching of the gains on the two inputs for exact cancellation of the interfering noise.
These charts are intended as selection guides only. For complete and precise specifications, consult the data sheet for each model.

### Semiconductor Charged-Particle Detectors

<table>
<thead>
<tr>
<th>Application</th>
<th>Recommended Preamplifier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy or Timing</td>
<td>Models 142A, 142B, or 142C are best. Final choice depends on capacitance of detector. Also see Model 142AH for special applications.</td>
</tr>
<tr>
<td>General</td>
<td>Model 142IH, a general-purpose, economical choice.</td>
</tr>
</tbody>
</table>

### Proportional Counters and Ionization Chambers

<table>
<thead>
<tr>
<th>Application</th>
<th>Recommended Preamplifier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Spectroscopy</td>
<td>Model 142PC is optimum. Model 142IH is the most cost-efficient choice for general-purpose applications.</td>
</tr>
</tbody>
</table>

### Photomultiplier Tubes, Electron Multipliers, Scintillation Detectors, Microchannel Plate PMTs, Microchannel Plates, Channeltrons, and Photodiodes

<table>
<thead>
<tr>
<th>Application</th>
<th>Recommended Preamplifier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time Spectroscopy</td>
<td>Model FTA820A (0 to –5 V output, rise time &lt;1 ns), 8 channels (octal) in a single wide NIM. Model VT120 (0 to –5 V output, rise time &lt;1 ns) is the best for fast PMTs and Electron Multipliers. It can also be used with Photodiodes, Microchannel Plate PMTs, Microchannel Plates, and Channeltrons. Model 9301 has ±0.7 V output, rise time &lt;1.5 ns. Model 9305 has variable gain, ±5 V output drive, dc-coupled (for high count rates), rise time &lt;3 ns. Model 9306 (0 to –2 V output, rise time = 350 ps) is best for Microchannel Plates and Channeltrons. It can also be used with fast PMTs and Photodiodes. Model 9309-4 has 0 to ±2 V output, rise time &lt;1.5 ns, dc-coupled (for high count rates), quad in a single wide NIM. Model 9310-16 has ±2 V output, rise time &lt;1.5 ns, dc-coupled (for high count rates). 16 in a single wide NIM. Model 9326 (+0.25 to –1 V output, rise time &lt;1 ns) is ideal for use with the FASTFLIGHT Digital Signal Averager, due to the 10 kHz low-frequency roll-off.</td>
</tr>
<tr>
<td>Energy Spectroscopy</td>
<td>Models 142A and 142AH are the ideal choices for Channeltrons, Micro-channel Plate PMTs, Microchannel Plates, and Photodiodes. Model 113 is a low-cost solution for PMTs and Scintillation detectors. Model 142IH is a general-purpose, economical choice.</td>
</tr>
</tbody>
</table>
### Charged-Particle Spectroscopy with Semiconductor Detectors

<table>
<thead>
<tr>
<th>Model</th>
<th>Detector Type</th>
<th>Features</th>
<th>Sensitivity (mV/MeV)</th>
<th>Equivalent Input Noise (FWHM)* Energy (Electrons at pF)</th>
<th>Rise Time (ns at pF)</th>
<th>Range (MeV)*</th>
<th>E2CRP (MeV/1s)*</th>
<th>Detector Bias Resistor (MΩ)</th>
<th>Maximum Detector Bias Voltage (Volts)</th>
</tr>
</thead>
<tbody>
<tr>
<td>142A</td>
<td>Si</td>
<td>Excellent timing and low noise for 0 to 100 pF detectors; high sensitivity and small size.</td>
<td>20 0.07 &lt;1.6 at 0 &lt;3.4 at 100 442 at 0 939 at 100 &lt;5 at 0 &lt;12 at 100 0–200</td>
<td>2 x 10 100 or 10</td>
<td>±1000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>142B</td>
<td>Si</td>
<td>Excellent timing and low noise for detector capacitances &gt;100 pF; small size.</td>
<td>10 0.04 &lt;3.2 at 100 &lt;19 at 1000 884 at 100 5249 at 1000 &lt;5 at 100 &lt;25 at 1000 0–100 5 x 10&lt;sup&gt;9&lt;/sup&gt;</td>
<td>100 or 10</td>
<td>±1000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>142C</td>
<td>Si</td>
<td>Excellent timing and low noise for detector capacitances &gt;400 pF; small size.</td>
<td>10 0.04 &lt;7.2 at 400 &lt;27 at 2000 1989 at 400 7459 at 2000 &lt;11 at 400 &lt;20 at 1000 0–400 5 x 10&lt;sup&gt;9&lt;/sup&gt;</td>
<td>100 or 10</td>
<td>±1000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>142AH</td>
<td>Si</td>
<td>Excellent timing and low noise for deep detectors; high bias voltage capability and high sensitivity.</td>
<td>20 0.07 &lt;1.75 at 0 &lt;3.6 at 100 483 at 0 994 at 100 &lt;5 at 0 &lt;12 at 100 0–100 2 x 10&lt;sup&gt;9&lt;/sup&gt;</td>
<td>100</td>
<td>±5000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>142H</td>
<td>Si</td>
<td>General-purpose, low-cost preamplifier.</td>
<td>15 0.05 1.9 at 0 4.6 at 100 35 at 1000 524 at 0 1270 at 100 9660 at 1000 &lt;20 at 0 &lt;50 at 100 0–100 8 x 10&lt;sup&gt;9&lt;/sup&gt;</td>
<td>100 or 10</td>
<td>±3000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Energies are referenced to 3.62 eV/e-h pair in silicon detectors and 2.96 eV/e-h pair in germanium detectors.

### Spectroscopy with Proportional Counters

<table>
<thead>
<tr>
<th>Model</th>
<th>Type</th>
<th>Features</th>
<th>Sensitivity (μV/Electron- ion pair)</th>
<th>Equivalent Input Noise (FWHM)* (Electrons at pF)</th>
<th>Rise Time (ns at pF)</th>
<th>Output Linear Range (V)</th>
<th>Detector Bias Resistor (MΩ)</th>
<th>Maximum Detector Bias Voltage (Volts)</th>
</tr>
</thead>
<tbody>
<tr>
<td>142H</td>
<td>PC</td>
<td>General-purpose, low-cost preamp suitable for use with charged-particle detectors, scintillation detectors, or proportional counters.</td>
<td>0.05 524 at 0 1270 at 100 223 at 0 540 at 100 &lt;20 at 0 &lt;50 at 100 7100 or 10 ±3000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>142PC</td>
<td>PC</td>
<td>Low-noise, high-gain, charge-sensitive unit designed for use with proportional counters.</td>
<td>0.6 &lt;800 at 0 &lt;1140 at 100 330 at 0 485 at 100 &lt;20 at 0 &lt;50 at 100 25 at 0 150 at 100 7 ±3000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note: FWHM = 2.35 x rms.
## Energy Spectroscopy with Scintillation Detectors, PMTs, Electron Multipliers, Microchannel Plates, Microchannel Plate PMTs, Channeltrons, and Photodiodes

<table>
<thead>
<tr>
<th>Model</th>
<th>Features</th>
<th>Sensitivity (μV/Electron)</th>
<th>Noise (rms)</th>
<th>Rise Time (ns)</th>
<th>Output Linear Range (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>113</td>
<td>Economical parasitic-capacitance preamplifier with selectable input capacitance to vary sensitivity.</td>
<td>$3.6 \times 10^{-10}$ to $1.5 \times 10^{-9}$</td>
<td>Output noise: $&lt;100$ μV</td>
<td>$&lt;60$</td>
<td>±7</td>
</tr>
<tr>
<td>142A</td>
<td>Fast rise time, charge-sensitive preamplifier for energy and time spectroscopy with microchannel plates, channeltrons, and photodiodes.</td>
<td>$7 \times 10^{-2}$</td>
<td>Input noise: 188 electrons at 0 pF, 400 electrons at 100 pF</td>
<td>$&lt;5$ at 0 pF, $&lt;12$ at 100 pF</td>
<td>±7</td>
</tr>
<tr>
<td>142AH</td>
<td>Use instead of Model 142A when a 1000-V to 3000-V bias voltage must be supplied through the preamplifier.</td>
<td>$7 \times 10^{-2}$</td>
<td>Input noise: 206 electrons at 0 pF, 423 electrons at 100 pF</td>
<td>$&lt;5$ at 0 pF, $&lt;12$ at 100 pF</td>
<td>±7</td>
</tr>
<tr>
<td>142H</td>
<td>General-purpose, charge-sensitive preamplifier; insensitive to variations in detector capacitance.</td>
<td>$5 \times 10^{-2}$</td>
<td>Input noise: 223 electrons at 0 pF, 450 electrons at 100 pF</td>
<td>$&lt;20$ at 0 pF, $&lt;50$ at 100 pF</td>
<td>±7</td>
</tr>
<tr>
<td>276</td>
<td>Parasitic-capacitance preamplifier incorporated in a 14-pin PMT base for 10-stage PMTs.</td>
<td>$1.6 \times 10^{-3}$</td>
<td>Output noise: $&lt;50$ μV</td>
<td>$&lt;100$</td>
<td>0 to +10</td>
</tr>
<tr>
<td>296</td>
<td>Parasitic-capacitance preamplifier incorporated with a detector bias supply in a 14-pin PMT base for 10-stage PMTs.</td>
<td>$2.7 \times 10^{-4}$ or $1.6 \times 10^{-3}$</td>
<td>Output noise: $&lt;300$ μV</td>
<td>$&lt;100$</td>
<td>0 to +6.5</td>
</tr>
</tbody>
</table>

## Fast Timing and Fast Counting with Scintillation Detectors, Photomultiplier Tubes, Electron Multipliers, Microchannel Plates, Microchannel Plate PMTs, Channeltrons, and Photodiodes

<table>
<thead>
<tr>
<th>Model</th>
<th>Features</th>
<th>Gain (V/V)</th>
<th>Input Impedance (Ω)</th>
<th>Equivalent Input Noise (μV rms)</th>
<th>Output Rise Time (ns)</th>
<th>Coupling</th>
<th>Output Linear Range (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VT120 A/B/C</td>
<td>Very fast rise time for use with PMTs, microchannel plates, microchannel plate PMTs, channeltrons, electron multipliers, and photodiodes. Note: FTA820A is 8 channels of VT120A in a single wide NIM.</td>
<td>A: 200 B: –200 C: 20</td>
<td>50</td>
<td>$&lt;20$</td>
<td>$&lt;1$</td>
<td>ac</td>
<td>0 to –5</td>
</tr>
<tr>
<td>9301</td>
<td>Very fast rise time for use with PMTs, microchannel plates, microchannel plate PMTs, channeltrons, electron multipliers, and photodiodes.</td>
<td>10</td>
<td>50</td>
<td>$&lt;25$</td>
<td>$&lt;1.5$</td>
<td>ac</td>
<td>±0.7</td>
</tr>
<tr>
<td>9305</td>
<td>Fast rise time for use with PMTs and electron multipliers. DC-coupled for baseline stability at high counting rates.</td>
<td>Variable 5 to 10</td>
<td>50</td>
<td>$&lt;30$</td>
<td>$&lt;3$</td>
<td>dc</td>
<td>±5</td>
</tr>
<tr>
<td>9306</td>
<td>Ultra-fast rise time for use with microchannel plate PMTs, microchannel plates, channeltrons, and photodiodes.</td>
<td>100</td>
<td>50</td>
<td>$&lt;100$</td>
<td>0.5</td>
<td>ac</td>
<td>0 to –2</td>
</tr>
<tr>
<td>9309-4</td>
<td>Fast rise time for use with PMTs and electron multipliers. DC-coupled for baseline stability at high counting rates. Quad in a single wide NIM.</td>
<td>Variable 0 to 10</td>
<td>50</td>
<td>$&lt;50$</td>
<td>$&lt;1.5$</td>
<td>dc</td>
<td>0 to ±2 V 2 outputs</td>
</tr>
<tr>
<td>9310-16</td>
<td>Fast rise time for use with PMTs and electron multipliers. DC-coupled for baseline stability at high counting rates. Octal in a single wide NIM.</td>
<td>10</td>
<td>50</td>
<td>$&lt;50$</td>
<td>$&lt;1.5$</td>
<td>dc</td>
<td>±2 V 2 outputs</td>
</tr>
<tr>
<td>9326</td>
<td>Very fast rise time, and 10-kHz low-frequency roll-off for use with FastFlight in TOF-MS. Use with microchannel plates, PMTs, electron multipliers, channeltrons, and photodiodes.</td>
<td>Selectable 5, 10 or 20</td>
<td>50</td>
<td>$&lt;100$</td>
<td>$&lt;1$</td>
<td>ac</td>
<td>0 to –1</td>
</tr>
</tbody>
</table>

Specifications subject to change 042213
The ORTEC Model 113 Scintillation Preamplifier is designed for use with photomultiplier tubes. The charge in the photomultiplier output pulse is integrated on the input capacitance of the preamplifier to produce a voltage pulse. A non-inverting voltage amplifier (gain = 1) drives this pulse into the output load. Switch selection of the input capacity permits control of the sensitivity of the preamplifier. The input capacity of the Model 113 is ~45 pF plus the capacity selected by the front-panel switch (0, 100, 200, 500, or 1000 pF). A diode network prevents destruction of the input transistor if a sudden positive or negative high voltage is applied to the input.

Specifications

**PERFORMANCE**

**RISE TIME** ~60 ns.

**PREAMPLIFIER FALL TIME** Fall time constant is designed for 50 μs, assuming a signal source impedance of 1 MΩ.

**INTEGRAL NONLINEARITY** ≤0.02%.

**TEMPERATURE COEFFICIENT** ±0.01%/°C, 0 to 50°C.

**COUNTING RATE** The gain shift of a 250-mV reference pulse is <0.25% with the application of an additional count rate of 65,000 counts/s of 200-mV random pulses.

**NOISE** <0.1 mV rms at output.

**CONTROL**

**INPUT CAP** Switch selects desired input capacity: 0, 100, 200, 500, or 1000 pF.

**INPUTS**

**INPUT** BNC connector; isolated for 1000 V; positive or negative polarity; input impedance is 45 pF plus the capacity selected by the front-panel switch (0, 100, 200, 500, or 1000 pF), shunted by the resistance needed to preserve a 50-μs decay time constant (see Fig. 1).

**TEST** BNC connector accepts a pulse generator output with fast rise and slow decay to check operation of the electronics; input impedance 100 Ω.

**OUTPUT**

BNC connector; output impedance adjustable from 40 to 140 Ω. Output saturation level ±10 V into open circuit; ±5.1 V into 100-Ω load. Linear output ±7 V into open circuit; ±3.5 V into 100-Ω load.

**ELECTRICAL AND MECHANICAL**

**POWER REQUIRED** +24 V dc, 17 mA; −24 V dc, 17 mA.

**WEIGHT** Net 0.65 kg (1.5 lb), Shipping 1.05 kg (2.3 lb).

**DIMENSIONS** 4.5 X 10.2 X 15.3 cm (1.75 X 4 X 6 in.).

**Related Equipment**

The Model 113 can be operated with any ORTEC shaping main amplifier. Test input pulses can be furnished from any ORTEC Pulse Generator.

**Ordering Information**

To order, specify:

**Model**

113 Scintillation Preamplifier

Suggested cable accessories:

- **C-24-1/2** RG-62A/U 93-Ω Cable with two BNC male plugs; 6-in. length
- **C-24-12** RG-62A/U 93-Ω Cable with two BNC male plugs; 12-ft length

![Fig. 1. Simplified Schematic of the Model 113.](image-url)
The ORTEC Models 142A, 142B, and 142C Preamplifiers are low-noise, fast-rise-time, charge-sensitive preamplifiers designed for optimum performance with charged-particle or heavy-ion detectors.

The Model 142A is optimized for extremely low noise and fast timing for detectors with capacitance up to 100 pF. This makes it the ideal selection for high-resolution alpha- and beta-particle spectroscopy applications.

Model 142B is optimized for extremely low noise and fast timing for detectors with capacitance greater than 100 pF but less than 400 pF. These preamplifiers have a separate fast-timing output with pulse widths of ~50 ns and rise times ranging from less than 5 ns for 0 pF detectors to less than 20 ns for 1000 pF detectors. This timing output, when used in conjunction with ORTEC’s standard electronics, provides excellent time resolution (Fig. 1); also, its fast-differentiated shape often permits direct coupling to the timing discriminator.

The performance of many spectroscopy systems can be enhanced by these preamplifiers being able to operate in vacuum enclosures. This allows the input cable length to be minimized. The small size of the preamplifiers is of significant importance when operating in such enclosures due to the limited space available.

Specifications

<table>
<thead>
<tr>
<th>PERFORMANCE*</th>
<th>NOISE (see Fig. 2)</th>
<th>Maximum Noise (keV) (Si)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>Detector Capacitance (pF)</td>
<td></td>
</tr>
<tr>
<td>142A</td>
<td>0</td>
<td>1.60</td>
</tr>
<tr>
<td>142A</td>
<td>100</td>
<td>3.40</td>
</tr>
<tr>
<td>142B</td>
<td>1000</td>
<td>19.00</td>
</tr>
<tr>
<td>142C</td>
<td>400</td>
<td>7.20</td>
</tr>
<tr>
<td>142C</td>
<td>1000</td>
<td>14.50</td>
</tr>
<tr>
<td>142C</td>
<td>2000</td>
<td>27.00</td>
</tr>
</tbody>
</table>

INTEGRAL NONLINEARITY <0.03%, 0 to ±7 V open circuit or ±3.5 V terminated in 93 Ω.

TEMPERATURE INSTABILITY
142A <±50 ppm/°C from 0 to 50°C.
142B <±100 ppm/°C from 0 to 50°C.
142C <±100 ppm/°C from 0 to 50°C.

OPEN LOOP GAIN
142A >40,000.
142B >80,000.
142C >80,000.

CHARGE SENSITIVITY (Si equivalent)
142A Nominally 20 mV/MeV.
142B Nominally 10 mV/MeV.
142C Nominally 10 mV/MeV.

ENERGY RANGE
142A 0–200 MeV.
142B 0–400 MeV.
142C 0–400 MeV.

E²CRP Maximum energy-squared count-rate product:
142A 2 X 10¹³ MeV²/s.
142B 5 X 10¹³ MeV²/s.
142C 5 X 10¹³ MeV²/s.

RISE TIME (0 to 0.5 V pulse at E output on 93 Ω load)
142A <5 ns at 0 pF; <12 ns at 100 pF.
142B <5 ns at 100 pF; <25 ns at 1000 pF.
142C <11 ns at 400 pF; <20 ns at 1000 pF.

DECAY TIME
142A Nominally 500 μs.
142B Nominally 1000 μs.
142C Nominally 1000 μs.

RECOMMENDED RANGE OF INPUT CAPACITANCE
142A 0 to 100 pF.
142B 100 to 400 pF.
142C 400 to 2000 pF.

DETECTOR BIAS VOLTAGE ±1000 V maximum.

*Performance specifications apply to E output unless stated otherwise.
142A, B, and C
Preamplifiers

Fig. 2. Typical Noise as a Function of Input Capacitance Measured with an ORTEC Model 572 Amplifier and 2-μs Time Constant.

Fig. 3. Typical Rise Time as a Function of Input Capacitance with Rise Time Compensation Optimized at Each Data Point. (Values given are for a +0.5-V signal into 93 Ω from the E channel.)

SILICON DETECTOR
Specific Capacitance in pF/mm²

INPUTS

INPUT Accepts positive or negative charge input (normally from a semiconductor detector) from any type detector; BNC connector.

BIAS Accepts detector bias from bias supply and applies it to detector through the INPUT connector; maximum ±1000 V; SHV connector or ORTEC type C-38.

TEST Input for pulse generator to test and calibrate the system; BNC connector.

POWER Input power through 10-ft captive power cable from ORTEC main amplifier or ORTEC Model 4002P Portable Power Supply.

OUTPUTS

E Positive or negative linear tail pulse for energy measurement. BNC connector.

T Negative or positive linear fast-clipped pulse for timing. This output is generated using an inverting transformer that differentiates the energy output. Its rise time ranges from <5 ns to <25 ns. BNC connector.

ELECTRICAL AND MECHANICAL

POWER REQUIRED

142A +24 V, 20 mA; −24 V, 10 mA;
+12 V, 15 mA; −12 V, 15 mA.

142B +24 V, 40 mA; −24 V, 10 mA;
+12 V, 15 mA; −12 V, 15 mA.

142C +24 V, 40 mA; −24 V, 10 mA;
+12 V, 15 mA; −12 V, 15 mA.

WEIGHT
Net 0.32 kg (0.75 oz).
Shipping 1.25 kg (2.75 lb).

DIMENSIONS 3.81 X 6.10 X 13.3 cm (1.5 X 2.4 X 5.25 in.).

SELECTION GUIDE TO 142A, 142B, OR 142C

To choose among Models 142A, 142B, or 142C:
1. Find the depletion depth of your detector. If it is an ORTEC detector, the last group of 2 to 4 digits is the depth in μm.
2. Find the depletion depth on the graph above and read the capacitance in pF/mm² on the top of the chart.
3. Multiply by the area of your detector in mm².

ORDERING INFORMATION

To order, specify:

Model Description
142A Preamplifier (for 0 to 100 pF)
142B Preamplifier (for 100 to 400 pF)
142C Preamplifier (for 400 to 2000 pF)

This is the middle 3-digit number for an ORTEC detector. Choose a Model 142A if the capacitance is less than 100 pF, a Model 142B if the capacitance is more than 100 pF but less than 400 pF, or a Model 142C if the capacitance is greater than 400 pF. Example: An ORTEC D-025-200-100 detector will have about 1 pF/mm² for its 100-μm depletion depth. This, then, is 200 pF for the 200 mm² area, and a Model 142B Preamplifier is preferred.

Specifications subject to change
030211
The ORTEC Model 142AH Preamplifier was designed to meet the needs of experimenters who require optimum performance from their charged-particle or heavy-ion detectors. This requirement is satisfied by the charge-sensitive Model 142AH through its extremely low noise and fast-timing characteristics. It is particularly suitable for high-energy charged-particle spectroscopy where high-resolution detectors with capacitances of up to 100 pF and bias voltages of up to 5000 V are involved.

Model 142AH has a separate fast-timing output signal approximately 50 ns wide with rise times ranging from <5 ns for 0 pF detectors to <12 ns for 100 pF detectors. This feature enables it to be directly coupled to a timing discriminator for some applications. When the Model 142AH is used in conjunction with ORTEC’s standard electronics, excellent timing resolution is obtained (Fig. 1).

### Specifications

#### PERFORMANCE

<table>
<thead>
<tr>
<th>Detector Capacity (pF)</th>
<th>Typical Noise (keV) (Si)</th>
<th>Warranted Noise (keV) (Si)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.55</td>
<td>1.75</td>
</tr>
<tr>
<td>20</td>
<td>1.65</td>
<td>—</td>
</tr>
<tr>
<td>50</td>
<td>2.35</td>
<td>—</td>
</tr>
<tr>
<td>100</td>
<td>3.35</td>
<td>3.60</td>
</tr>
</tbody>
</table>

**INTEGRAL NONLINEARITY** $<\pm 0.05\%$ for 0 to ±7 V open circuit, or ±3.5 V terminated in 93 Ω.

**TEMPERATURE INSTABILITY** $<\pm 50 \text{ ppm/°C}$ from 0 to 50°C.

**OPEN LOOP GAIN** $>40,000$.

**CHARGE SENSITIVITY (Si equivalent)** Nominally 20 mV/MeV.

**RISE TIME** (Fig. 3) $<5$ ns at 0 pF; $<12$ ns at 100 pF; with a 0 to +0.5-V pulse at the ENERGY output and a 93-Ω load.

**DECAY TIME** $\approx 500 \mu$s.

**RECOMMENDED INPUT CAPACITY RANGE** 0 to 100 pF.

**PERMISSIBLE OUTPUT CABLE LENGTH** Limited only by cable losses (recommended cable: ENERGY output, RG-71A/U or RG-62A/U; TIMING output, RG-58).

**E^2CRP** Maximum energy-squared count rate product: $2 \times 10^7$ MeV²/s.

**DETECTOR BIAS VOLTAGE** ±5000 V.

**OUTPUT LEVELS AND LOADING** All specifications are stated for open-circuit output and remain unchanged for 93-Ω termination or cable loading, except saturated output levels are half the open-circuit values. Saturated output level, ±10 V; integral nonlinearity specified to ±7 V.

*Performance specifications are for the ENERGY output unless stated otherwise.

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Fig. 1. Typical Time Resolution vs. Energy for 90 and 27 pF Detectors with ORTEC Standard Electronics.
142AH Preamplifier

INPUTS

INPUT Accepts positive or negative charge input from any type of detector (normally from a semiconductor detector); SHV connector.

BIAS Accepts detector bias from bias supply and applies it to the detector through a filter network via the INPUT connector; maximum ±5000 V; SHV connector or ORTEC C-38.

TEST Input for pulse generator to test and calibrate the system; BNC connector.

POWER Input power through 3-m (10-ft) captive power cable from any ORTEC main amplifier or from an ORTEC Model 4002P Portable Power Supply.

OUTPUTS

ENERGY Positive or negative linear tail pulse for energy measurement; BNC connector.

TIMING Negative or positive linear fast-clipped pulse for timing. Output generated by using an inverting transformer which differentiates the energy output. Rise time approximately equal to the rise time of the energy output (Fig. 3); BNC connector.

ELECTRICAL AND MECHANICAL

POWER REQUIRED +24 V, 30 mA; –24 V, 10 mA; +12 V, 15 mA; –12 V, 15 mA.

WEIGHT Net 0.45 kg (1 lb).

Shipping 1.3 kg (3 lb).

DIMENSIONS 4.45 X 10.16 X 13.21 cm (1.75 X 4.0 X 5.2 in.).

Ordering Information

To order, specify:

Model Description
142AH Preamplifier

Suggested cable accessories:

C-24-12 RG-62A/U 93-Ω Cable with two BNC male plugs; 12-ft length
C-25-12 RG-58A/U 50-Ω Cable with two BNC male plugs; 12-ft length
C-36-2 RG-59A/U 75-Ω Cable with two SHV female plugs, 2-ft length
C-36-12 RG-59A/U 75-Ω Cable with two SHV female plugs, 12-ft length

Specifications subject to change
03/2/11
The ORTEC Model 142IH Charge-Sensitive Preamplifier is an economical and general-purpose instrument that can be used for universal applications such as x-ray, low and high-energy gamma-ray spectroscopy, and also for alpha and other charged-particle spectroscopy.

The Model 142IH may be used with semiconductor radiation detectors, proportional counters, ionization chambers, and low-gain photomultiplier tubes.

Specifications

<table>
<thead>
<tr>
<th>PERFORMANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOISE</td>
</tr>
</tbody>
</table>
| Increases with increasing input capacitance. Typical slope, 0 to 100 pF = 27 eV/pF; 100 pF to 1000 pF = 34 eV/pF. Typical performance values, based on silicon equivalent of \( \epsilon = 3.6 \) eV at \( \tau = 2 \) μs, are 1.9 keV at 0 pF; these become 4.8 keV at 100 pF and 35 keV at 1000 pF.

| RISE TIME   |
| Based on a +0.5 V signal through either output into a 93-Ω circuit and measured from 10% to 90% of peak amplitude; <20 ns at 0 pF and <50 ns at 100 pF.

| SENSITIVITY |
| Nominal, measured through either output, 15 mV/MeV Si.

| ENERGY RANGE|
| 0 to 100 MeV Si.

| E2CRP       |
| Maximum energy-squared count-rate product: 8 X 10^7 MeV^2/s.

| DYNAMIC INPUT CAPACITANCE |
| 10,000 pF.

| INTEGRAL NONLINEARITY   |
| ≤±0.05% for 0 to ±7 V open circuit or ±3.5 V terminated in 93 Ω.

| TEMPERATURE INSTABILITY |
| ≤±100 ppm/°C, 0 to 50°C.

| DETECTOR BIAS ISOLATION |
| ±3000 V.

| OPEN LOOP GAIN |
| ≥40,000.000.

Inputs

| INPUT |
| Accepts input signal from a detector and extends operating bias to the detector.

| BIAS |
| Accepts the bias voltage for the detector from a bias supply.

| TEST |
| Accepts input voltage pulses from a check and calibration; \( R_{in} = 93 \) Ω.

Outputs

| E AND T (for Energy and Timing) |
| 2 connectors furnish identical signals through 2 output paths; either or both of these outputs can be used as required, and they are interchangeable. \( R_{in} = 93 \) Ω through each connector, and the output polarity is opposite from the input pulse polarity (output pulse polarity is the same as bias polarity).

Connectors

| INPUT AND BIAS |
| SHV.

| TEST, E, AND T |
| BNC.

Power Cable

| 3-m (10-ft) captive power cable, ORTEC 121-C1; longer lengths available on special order.

Electrical and Mechanical

| POWER REQUIRED |
| +24 V, 30 mA; −24 V, 10 mA; +12 V, 15 mA; −12 V, 15 mA. Furnished from NIM bin and power supply through any ORTEC main amplifier or from an ORTEC Model 4002P Portable Power Supply; built-in captive cable is compatible with either source.

| WEIGHT |
| Net 0.45 kg (1 lb). Shipping 1.3 kg (3 lb).

| DIMENSIONS |
| 3.8 X 6.1 X 13.3 cm (1.5 X 2.4 X 5.25 in.) plus 3-m (10-ft) cable.

Ordering Information

To order, specify:

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>142IH</td>
<td>Preamplifier</td>
</tr>
</tbody>
</table>

Suggested cable accessories:

<table>
<thead>
<tr>
<th>C-24-12</th>
<th>RG-62/U 93-Ω Cable with two BNC male plugs; 12-ft length</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-36-2</td>
<td>RG-59/U 75-Ω Cable with two SHV female plugs, 2-ft length</td>
</tr>
<tr>
<td>C-36-12</td>
<td>RG-59/U 75-Ω Cable with two SHV female plugs, 12-ft length</td>
</tr>
</tbody>
</table>

Specifications subject to change 03/211
The ORTEC Model 142PC Preamplifier is a low-noise charge-sensitive unit especially designed for use with proportional counters requiring up to ±3000 V detector bias.

The high sensitivity of this unit often allows operating the proportional counter at reduced voltages, thus greatly minimizing peak position shifts and peak broadening with changing count rates.

The low-noise performance for this type of preamplifier greatly improves the resolution of the spectroscopy system. The separate energy and timing outputs enhance instrument flexibility.

The Model 142PC incorporates a protection circuit for the input FET to prevent damage from inadvertently applied overvoltages. The unit is shipped with the protection circuit in place; better resolution, however, will be obtained when the protection is removed (Fig. 1).

**Specifications**

**PERFORMANCE**

<table>
<thead>
<tr>
<th>Noise</th>
<th>Typical</th>
<th>Guaranteed</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 pF</td>
<td>295 rms electrons</td>
<td>&lt;340 rms electrons</td>
</tr>
<tr>
<td>100 pF</td>
<td>450 rms electrons</td>
<td>&lt;485 rms electrons</td>
</tr>
</tbody>
</table>

**RISE TIME** Based on a +0.5 V signal through either output into a 93-Ω circuit and measured from 10% to 90% of peak amplitude; 25 ns at 0 pF and 150 ns at 100 pF.

**SENSITIVITY** Nominal, measured through either output, 4 V/pC.

**DYNAMIC INPUT CAPACITANCE** 1000 pF.

**INTEGRAL NONLINEARITY** ±0.05% for 0 to ±7 V open circuit or ±3.5 V terminated in 93 Ω.

**OUTPUT LINEAR RANGE** ±7 V.

**TEMPERATURE INSTABILITY** ±50 ppm/°C, 0 to 50°C.

**DETECTOR BIAS ISOLATION** ±3000 V.

**OPEN LOOP GAIN** ≥40,000.

**INPUTS**

**INPUT** Accepts input signals from a proportional counter and extends operating bias to the proportional counter.

**BIAS** Accepts the bias voltage for the proportional counter from a bias supply.

**TEST** Accepts input voltage pulses from a pulse generator for instrument and system check and calibration; Rin = 93 Ω.

**OUTPUTS**

**ENERGY AND TIMING** 2 connectors furnish identical signals through 2 output paths; either or both of these outputs can be used as required, and they are interchangeable. Rin = 93 Ω through each connector, and the output polarity is opposite from the input pulse polarity (output pulse polarity is the same as bias polarity).

**CONNECTORS**

**INPUT AND BIAS** SHV.

**TEST, ENERGY, AND TIMING** BNC.

**POWER CABLE** 3-m (10-ft) captive power cable, ORTEC 121-C1; longer lengths available on special order.

**ELECTRICAL AND MECHANICAL**

**POWER REQUIRED** +24 V, 30 mA; –24 V, 10 mA; +12 V, 15 mA; –12 V, 15 mA.

Furnished from NIM bin and power supply through any ORTEC main amplifier or from an ORTEC Model 4002P Portable Power Supply; built-in captive cable is compatible with either source.

**WEIGHT**

Net 0.65 kg (1.5 lb).

Shipping 1.3 kg (3.0 lb).

**DIMENSIONS** 4.5 X 13.2 X 10.0 cm (1.75 X 5.2 X 4.0 in.) plus 3-m (10-ft) cable.

**Ordering Information**

To order, specify:

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>142PC</td>
<td>Preamplifier</td>
</tr>
</tbody>
</table>

Suggested cable accessories:

- C-24-12 RG-62/U 93-Ω Cable with two BNC male plugs; 12-ft length
- C-36-2 RG-59/U 75-Ω Cable with two SHV female plugs; 2-ft length
- C-36-12 RG-59/U 75-Ω Cable with two SHV female plugs; 12-ft length

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**Fig. 1.** Noise as a Function of Input Capacitance, Measured with an ORTEC Model 572 Amplifier and 2-μs Time Constant.
The ORTEC Model 9301 low-noise, fast-rise-time Preamplifier has been designed for use with photomultipliers, electron multipliers, and other detectors employed in photon counting, ion counting, or fast-timing applications. When connected to the detector, the 50-Ω input resistance of the Model 9301 provides a load resistance for the detector output current pulse.

In addition to its fast rise time of 1.5 ns, this preamplifier has a voltage gain of 10 and an output impedance of 50 Ω. Because of its compact size and lightweight, the Model 9301 is ideal for mounting directly or close to a detector. Consequently, low-level signals, which would otherwise be susceptible to pickup of noise or interference, are boosted to a suitable level for cable connection to the main amplifier. Connection to a power supply is through the 3-m (10-ft) long captive power cable furnished with the Model 9301.

Model 9301 is fitted with a power cable connector (Amphenol 17-20090) that is compatible with other ORTEC NIM-standard modules.

Specifications

<table>
<thead>
<tr>
<th>PERFORMANCE</th>
<th>INPUT IMPEDANCE</th>
<th>50 Ω.</th>
</tr>
</thead>
<tbody>
<tr>
<td>VOLTAGE GAIN</td>
<td>10 (±2%) noninverting.</td>
<td></td>
</tr>
<tr>
<td>RISE TIME</td>
<td>&lt;1.5 ns.</td>
<td></td>
</tr>
<tr>
<td>INPUT RMS NOISE EQUIVALENT</td>
<td>&lt;25 μV.</td>
<td></td>
</tr>
<tr>
<td>OUTPUT IMPEDANCE</td>
<td>Typically 50 Ω.</td>
<td></td>
</tr>
<tr>
<td>OUTPUT DYNAMIC RANGE</td>
<td>&gt;±0.7 V into 50 Ω.</td>
<td></td>
</tr>
<tr>
<td>NONLINEARITY</td>
<td>&lt;±1%.</td>
<td></td>
</tr>
<tr>
<td>TEMPERATURE GAIN INSTABILITY</td>
<td>&lt;±0.1%/°C.</td>
<td></td>
</tr>
<tr>
<td>INPUT CONNECTOR</td>
<td>Front-panel BNC.</td>
<td></td>
</tr>
<tr>
<td>OUTPUT CONNECTOR</td>
<td>Rear-panel BNC.</td>
<td></td>
</tr>
</tbody>
</table>

ELECTRICAL AND MECHANICAL

POWER REQUIRED | +12 V, 30 mA; −12 V, 30 mA. |
WEIGHT | Net 0.17 kg (6 oz). |
| Shipping 0.9 kg (~2 lb). |
DIMENSIONS | 3.1 X 5.0 X 7.3 cm (1.25 X 2 X 2.875 in.) plus 3-m (10-ft) cable. |

Ordering Information

To order, specify:

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>9301</td>
<td>Preamplifier</td>
</tr>
</tbody>
</table>

Suggested cable accessories:

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-25-1/2</td>
<td>RG-58A/U 50-Ω Cable with two BNC male plugs; 6-in. length</td>
</tr>
<tr>
<td>C-25-12</td>
<td>RG-58A/U 50-Ω Cable with two BNC male plugs; 12-ft length</td>
</tr>
</tbody>
</table>

Specifications subject to change 092407
The ORTEC Model 9305 Fast Preamplifier contains a direct-coupled wideband hybridized amplifier suitable for use with photomultipliers, electron multipliers, and other detectors used in photon counting, ion counting, or fast-timing applications.

In addition to the fast rise time (<3 ns), Model 9305 has a variable voltage gain of 5–10 and can drive ±5 V into a 50-Ω load. The 9305 also features excellent dc gain stability along with low noise and <5 ns overload recovery time. Overload input protection is provided also.

Specifications

**PERFORMANCE**

- **NOMINAL VOLTAGE GAIN** 5–10, non-inverting.
- **RISE TIME** <3 ns to ±5 V into 50 Ω; bandwidth >120 MHz.
- **NOISE** <25 μV referred to the input measured with an HP3400A true rms voltmeter. Wideband noise (200 MHz) <30 μV referred to the input.
- **INTEGRAL NONLINEARITY** Typically ≤±1% for output to ±5 V.
- **PULSE OVERLOAD RECOVERY** Typically ≤5 ns for a X10 overload.
- **GAIN INSTABILITY** Typically ≤±0.05%/°C.
- **DC INSTABILITY** Typically ≤±150 μV/°C referred to the output.

**CONTROLs**

- **BDW** 20-turn potentiometer adjusts the output bandwidth and overshoot. Front-panel mounted.
- **DC** 20-turn potentiometer adjusts the output dc offset. Front-panel mounted.
- **GAIN** 20-turn potentiometer adjusts the voltage gain from typically 5 to 10. Front-panel mounted.

**ELECTRICAL AND MECHANICAL**

- **POWER REQUIRED** +12 V, 67 mA; −12 V, 67 mA.
- **WEIGHT** Net 0.32 kg (12 oz), Shipping 1.25 kg (2 lb 12 oz).
- **DIMENSIONS** 3.81 X 6.1 X 8.89 cm (1.5 X 2.4 X 3.5 in.).

**Ordering Information**

To order, specify:

- **Model** Description
  - 9305 Fast Preamplifier

Suggested cable accessories:

- **C-25-1/2** RG-58A/U 50-Ω Cable with two BNC male plugs; 6-in. length
- **C-25-12** RG-58A/U 50-Ω Cable with two BNC male plugs; 12-ft length

Hybrid circuit technology gives the Model 9305 high performance and reliability. For operator convenience independent bandwidth (BDW), output dc offset (DC), and fine gain (GAIN) adjustments are included.

Because of its compact size and light weight, the Model 9305 is ideal for mounting directly on or close to a detector. Consequently, low-level signals which would otherwise be susceptible to distortion by noise or interference are amplified to a suitable level for cable connection to the main amplifier.

Connection to a power supply is through a 10-ft cable furnished with the Model 9305.
• 1-GHz preamplifier for timing applications with pulses from ultra-fast detectors (microchannel plates, microchannel-plate photomultipliers, channeltrons, silicon diodes, photomultipliers, and electron multipliers)
• 350-ps rise time
• Gain ≈ 100 (non-inverting)
• 100-kHz to 1-GHz bandwidth
• Two identical outputs deliver 0 to –2 V pulses on 50-Ω loads
• 50-Ω input and output impedances, ac-coupled

The ORTEC Model 9306 1-GHz Preamplifier is optimized for fast timing and counting applications with detectors that deliver pulses with ultra-fast rise times. An output rise time of 350 ps and a non-inverting gain of 100 make the Model 9306 ideal for use with microchannel plates, microchannel-plate photomultipliers, channeltrons, silicon diodes, fast photomultiplier tubes, and electron multipliers. The compact preamplifier case with captive power cord permits close coupling to the detector to minimize sensitivity to environmental noise.

To preserve the ultra-fast rise time, the Model 9306 is designed to accept and deliver signals on high-quality, 50-Ω coaxial cables with SMA connectors and 50-Ω terminations. The input is ac-coupled, with a 50-Ω input impedance, and is protected to a maximum of ±1 V. Two identical outputs are provided for convenient, simultaneous connection to two different instruments. Both outputs are ac-coupled, short-circuit protected, and capable of driving pulse amplitudes from 0 to –2 V into 50-Ω loads.

The Model 9306 1-GHz Preamplifier derives its +24-V dc power from a NIM module or power supply via the captive power cord and standard, 9-pin, D connector. The ORTEC Model 4002P Portable Power Supply and most NIM amplifiers provide the required power on a compatible preamplifier power connector.

Simplified Functional Block Diagram of the Model 9306.
Specifications

In the specifications, all electrical values are measured using a pulser having a pulse width of 2 ns (90%–10% FWHM) and a rise time of 150 ns. Where significant, the measurement is corrected for the rise times of the pulser, coaxial cable, and oscilloscope. The specifications are identical for OUTPUTS 1 and 2.

GAIN Nominally 100 (50 to 150), non-inverting, into a 50-Ω output load.

OUTPUT RISE TIME Typically 350 ps.

BANDWIDTH (3 dB) Typically 100 kHz to 1 GHz.

NOISE <100 μV rms equivalent input noise over the full bandwidth.

INPUT AND OUTPUTS

INPUT SMA input connector with 50-Ω input impedance (ac-coupled) and a 10-kΩ resistance to ground. Input protected to a maximum of ±1 V.

OUTPUT 1 SMA output connector provides a linear output range from 0 to –1.75 V and a maximum output of –2 V into a 50-Ω load. Output impedance is 50-Ω, ac-coupled, and short-circuit protected. The unused output must be terminated with a 50-Ω load for proper operation of the other output. An optional SMA 50-Ω terminator is available for this purpose.

OUTPUT 2 Identical to OUTPUT 1.

POWER Input power is supplied through a captive cable (length: 3 m) with a standard preamplifier power connector (9-pin D type). Compatible with ORTEC instruments that provide a preamplifier power connector.

ELECTRICAL AND MECHANICAL

POWER REQUIRED +24 V at 200 mA. Captive power cord with standard 9-pin D connector derives power from any ORTEC instrument equipped with the standard preamplifier power plug (e.g., spectroscopy amplifiers, 4002P Portable Power Supply, 9307 pico-TIMING Discriminator, etc.).

WEIGHT Net 0.2 kg (0.4 lb). Shipping 1.1 kg (2.4 lb).

DIMENSIONS Aluminum housing 9.5 X 6.4 X 2 cm (3.75 X 2.5 X 0.8 in.).

Ordering Information

To order, specify:

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>9306</td>
<td>1-GHz Preamplifier</td>
</tr>
<tr>
<td>SMA50</td>
<td>50-Ω SMA Terminator (male). Required to load the unused output with 50 Ω.</td>
</tr>
<tr>
<td>SMA58-0.15</td>
<td>RG-58A/U (50-Ω) Coaxial Cable with SMA Connectors, 0.15-m length</td>
</tr>
<tr>
<td>SMA58-0.5</td>
<td>RG-58A/U (50-Ω) Coaxial Cable with SMA Connectors, 0.5-m length</td>
</tr>
<tr>
<td>SMA58-1.5</td>
<td>RG-58A/U (50-Ω) Coaxial Cable with SMA Connectors, 1.5-m length</td>
</tr>
<tr>
<td>SMA/BNC</td>
<td>SMA to BNC Adapter with male SMA and female BNC</td>
</tr>
<tr>
<td>BNC/SMA</td>
<td>BNC to SMA Adapter with male BNC and female SMA</td>
</tr>
</tbody>
</table>

Optional Accessories

The Model 9306 is designed for use with 50-Ω coaxial signal cables having SMA connectors. The desired optional cables and adapters can be selected from the ordering information. To avoid degradation of the 350-ps rise time through long signal cables, the total length of the input and output signal cables should be ≤1.7 m. If one of the outputs is not used, it must be loaded with an SMA50 terminator.

The Model 9306 should be used with the Model 9307 pico-TIMING™ Discriminator for optimum time resolution with ultra-fast detectors.

Specifications subject to change 092407

ORTEC® www.ortec-online.com
Tel. (865) 482-4411 • Fax (865) 483-0396 • ortec.info@ametek.com
801 South Illinois Ave., Oak Ridge, TN 37831-0895 U.S.A.
For International Office Locations, Visit Our Website
The Model 9326 Fast Preamplifier is optimized for amplifying the pulses from microchannel-plate detectors, electron multipliers, photomultiplier tubes, fast photodiodes, and silicon charged-particle detectors. The fast rise times of these detectors are preserved by the <1-ns rise time of the Model 9326 output, which can supply 0 to –1-V pulse amplitudes into a 50-Ω load. The compact size permits placement close to the detector in order to avoid ground loop and environmental noise interference with the small signals produced by the detector. Gains of 5, 10, or 20 volts/volt (non-inverting) can be selected via a board jumper.

A low-frequency roll-off less than 10 kHz is unusual for a preamplifier intended for processing fast detector pulses. This low-frequency response was incorporated in order to virtually eliminate pulse undershoot when used with the FASTFLIGHT™ Digital Signal Averager in the Electrospray Time-of-Flight Mass Spectrometry application.

To minimize damage caused by large transients from the detector, the input incorporates overload protection. The output is also short-circuit protected.

Specifications

**PERFORMANCE**

**INPUT NOISE** <100 μV rms.

**OUTPUT RISE TIME** <1 ns.

**LOW FREQUENCY ROLL-OFF** <10 kHz.

**GAIN** Selectable by board jumpers for 5, 10, or 20 V/V. The overall gain is non-inverting.

**OPERABLE TEMPERATURE RANGE** 0–50°C.

**CONTROLS**

**COARSE GAIN** Board jumper selection of low (5 V/V), medium (10 V/V), or high (20 V/V) gain.

**INPUTS**

**ANALOG INPUT** Front-panel BNC connector accepts negative-polarity analog signals in the range of 0 to –200 mV. Input impedance: 50 Ω ac, <1000 Ω dc to ground. Diode clamps provide protection against overload to ±2 V dc, or ±10 V for a 50-ns-wide pulse at a duty cycle of <1%.

**OUTPUTS**

**ANALOG OUTPUT** Rear-panel BNC connector provides a negative-polarity output pulse. Linear range is nominally +0.25 V to –1 V on a 50-Ω load. AC-coupled and short-circuit protected.

**POWER REQUIREMENTS** The required +12 V at 100 mA dc power can be supplied from any ORTEC preamplifier power connector via the 3-m (9.8-ft) long power cord included with the Model 9326. The mating connectors on the ends of the power cord are ORTEC-standard, 9-pin D, preamplifier power connectors. Pin assignments for the male connector on the preamplifier case are +12 V on pin 4, and ground on pins 1 and 2.

**WEIGHT**

- Net 0.39 kg (0.85 lb).
- Shipping 1.3 kg (2.9 lb).

**PACKAGE AND DIMENSIONS** Compact preamplifier box: 8.6 cm W x 13.3 cm D x 3.0 cm H (3.4 in. W x 5.3 in. D x 1.2 in. H).

**Ordering Information**

To order, specify:

**Model** 9326

**Description** Fast Preamplifier (includes power cable)

Specifications subject to change

122707
For amplifying fast analog signals from photomultipliers, electron multipliers, photodiodes, microchannel plates, and silicon charged-particle detectors

- ≤1 ns rise time
- Gain: 200
- Output drives −5 V into 50 Ω
- Eight separate and identical amplifiers in a single-width NIM
- ≤20 μV rms equivalent input noise

The FTA820A Amplifier is a high-performance, wide-bandwidth amplifier designed for boosting very fast linear signals from photomultipliers, electron multipliers, silicon charged-particle detectors, and other detectors used in fast timing applications. The rise time is <1 ns with a 5-V output, enabling excellent timing resolution.

The FTA820A provides eight separate and identical amplifiers in a single-width NIM module. Each FTA820A amplifier section has a gain of 200, noninverting, LEMO type 00C50 connectors are used for all signal connections.

### Specifications

**Performance**

- **Gain for each channel**: (10% gain tolerance) 200, noninverting.
- **Number of channels**: 8.
- **Rise time**: ≤1 ns.
- **Noise**: ≤20 μV rms equivalent input noise.
- **Bandwidth**: 10 to 350 MHz.
- **Propagation Delay**: ≤30-ps variation between channels.
- **Output range**: 0 to −5 V with 50-Ω load.
- **Inputs**: One for each channel. LEMO connector; input impedance 50 Ω.
- **Outputs**: One for each channel. LEMO connector; 0 to −5 V output with a 50-Ω load. Output impedance ≤1 Ω.

**Electrical and Mechanical**

- **Power required**: +12 V, 400 mA.
- **Dimensions**: Standard single-width NIM module 3.43 X 22.13 cm (1.35 X 8.714 in.) per DOE/ER-0457T.
- **Weight**: Net 1 kg (2.2 lb). Shipping 2.7 kg (5.9 lb).

### Ordering Information

To order, specify:

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FTA820A</td>
<td>Octal Fast Timing Amplifier</td>
</tr>
<tr>
<td></td>
<td>(200 gain, noninverting)</td>
</tr>
</tbody>
</table>

www.ortec-online.com

Tel. (865) 482-4411 • Fax (865) 483-0396 • ortec.info@ametek.com
801 South Illinois Ave., Oak Ridge, TN 37831-0895 U.S.A.
For International Office Locations, Visit Our Website