TAx Fast Pulse / Timing Preamplifier Comparison Sheet x5/x10/x20/x40/x50/x80/x100/x200, DC coupled

TAx Family Overview

Family	Type	Nominal Gain [V/V]	Nominal Gain [dB]	Small Signal Bandwidth (-3dB)	50 Ohm Output Option: Small Signal Bandwidth (-3dB)
				(0) (1)	(0) (1)
Very Low Noise	TA1000B-10 BWL(6)	10	20dB	170MHz	200MHz
	TA1000B-10	10	20dB	710MHz	850MHz
	TA1000B-50 BWL(6)	50	34dB	245MHz	245MHz
	TA1000B-50	50	34dB	1000MHz	1000MHz
	TA1000B-100 BWL(6)	100	40dB	245MHz	245MHz
	TA1000B-100	100	40dB	950MHz	990MHz
	TA1000B-200 BWL(6)	200	46dB	110MHz	110MHz
	TA1000B-200	200	46dB	400MHz	400MHz
Low Noise, High Bandwidth	TA2400	5	14dB	2200MHz	2800MHz
	TA1800B	10	20dB	1700MHz	2100MHz
High Bandwidth, High Gain	TA2000B-1	20	26dB	2000MHz	2280MHz
	TA2000B-2	40	32dB	1700MHz	2000MHz
	TA2000B-3	80	38dB	1500MHz	1700MHz

Comparison and Selection Chart

Type	Nominal Gain [V/V]	Nominal Gain [dB]	Small Signal Band-width (-3dB)	Gain Flatness	Peaking (100ps Rise Time Input Pulse)	Noise Figure (100MHz)	Input Referred Broadband Noise (DC ... 12.5GHz)		Input Referred LF Noise (20Hz ... 1MHz)
			(0) (1)	(0) (1)	(0) (2)		(3) (4)	(4)	(5)
TA2400	5	14dB	2200MHz	0.00dB	0%	16dB	111.1µV_{rms}	0.528mV_{p-p}	3.2µV_{rms}
TA1800B	10	20dB	1700MHz	0.00dB	0%	16dB	107.7µV_{rms}	0.924mV_{p-p}	2.5µV_{rms}
TA1000B-10	10	20dB	710MHz	0.00dB	6%	8dB	51.2µV_{rms}	0.224mV_{p-p}	0.3µV_{rms}
TA1000B-10 BWL(6)	10	20dB	170MHz	0.00dB	0%		30.2µV_{rms}	0.124mV_{p-p}	
TA2000B-1	20	26dB	2000MHz	0.29dB	7%	17dB	135.0µV_{rms}	1.202mV_{p-p}	3.7µV_{rms}
TA2000B-2	40	32dB	1700MHz	0.32dB	7%	17dB	109.7µV_{rms}	1.166mV_{p-p}	4.0µV_{rms}
TA1000B-50	50	34dB	1000MHz	0.22dB	9%		57.8µV_{rms}	0.541mV_{p-p}	0.5µV_{rms}
TA1000B-50 BWL(6)	50	34dB	245MHz	0.00dB	0%		36.6µV_{rms}	0.509mV_{p-p}	
TA2000B-3	80	38dB	1500MHz	0.36dB	7%	17dB	104.6µV_{rms}	1.338mV_{p-p}	5.4µV_{rms}
TA1000B-100	100	40dB	950MHz	0.12dB	8%		55.9µV_{rms}	0.542mV_{p-p}	12.3µV_{rms}
TA1000B-100 BWL(6)	100	40dB	245MHz	0.00dB	0%		34.2µV_{rms}	0.318mV_{p-p}	
TA1000B-200	200	46dB	400MHz	0.00dB	0%		31.2µV_{rms}	0.331mV_{p-p}	13.6µV_{rms}
TA1000B-200 BWL(6)	200	46dB	110MHz	0.00dB	0%		23.1µV_{rms}	0.223mV_{p-p}	

(0) Simulation Results

(1) Signal input: sine wave = 200mVeff / "nominal Gain"

(2) Output Pulse Height approx. 200mVp-p, Input Rise Time 100ps

(3) defined as RMSΔ = σ = standard deviation, ref. scope pictures of output noise voltages below

(4) in 40 minutes accumulated with a 12.5GHz sampling head, ref. scope pictures of output noise voltages below

(5) measured with a HP3455A True RMS Voltmeter, this is mostly the 1/f noise

(6) BWL = Bandwidth limited option (with improved noise performance)

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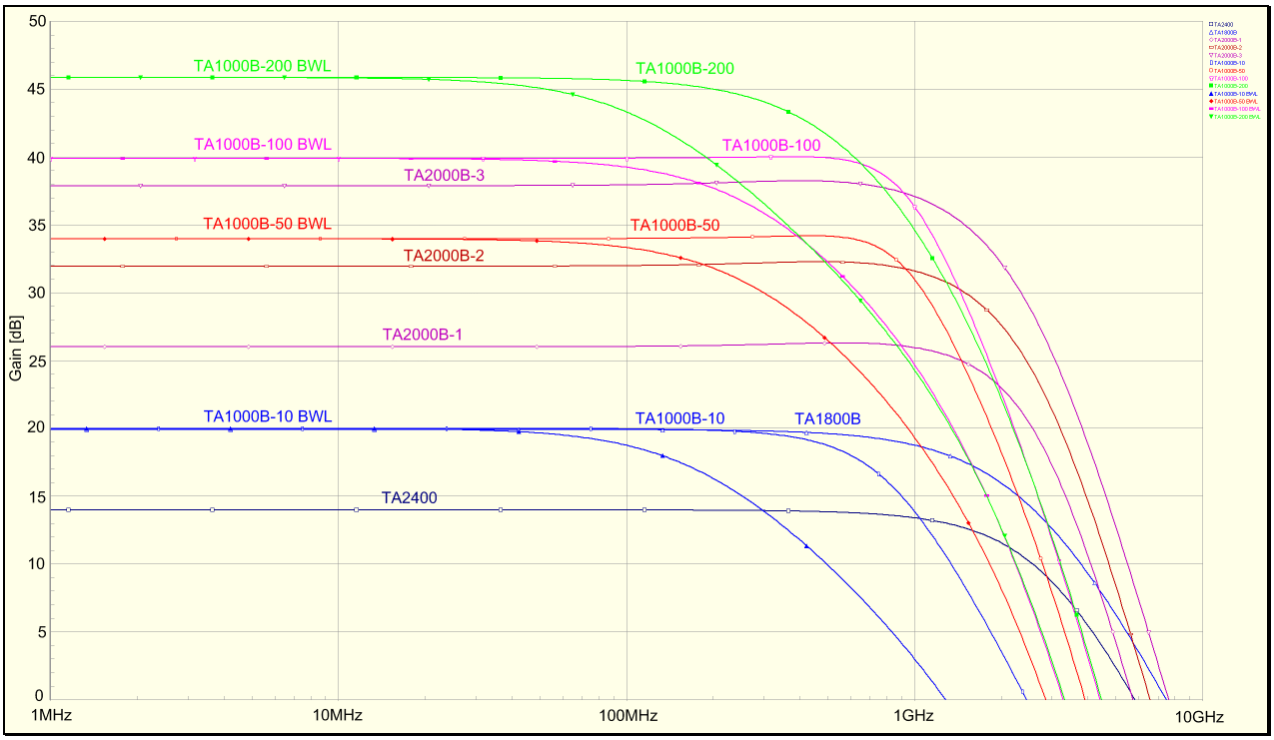
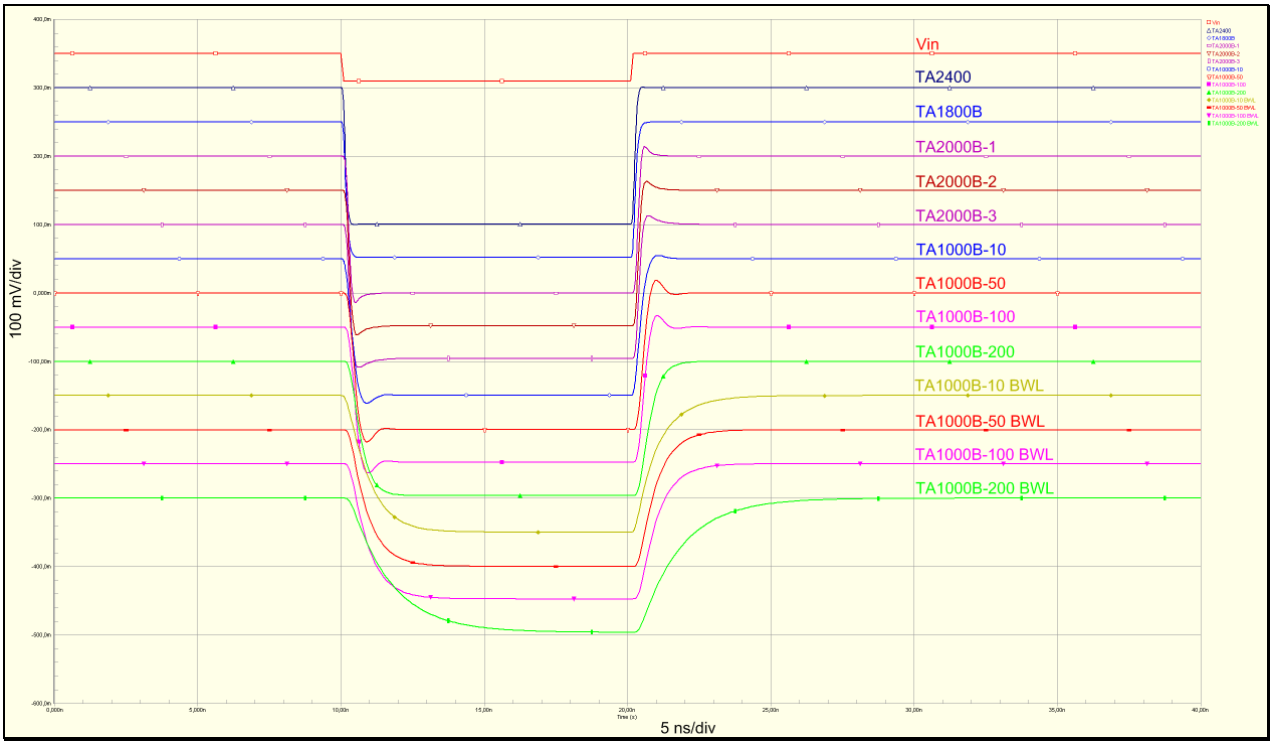
Simulated Voltage Gain



(*) 200mVeff output signal into 50Ω load

Simulated Pulse Response



(*) Signals are voltage shifted for better comparison

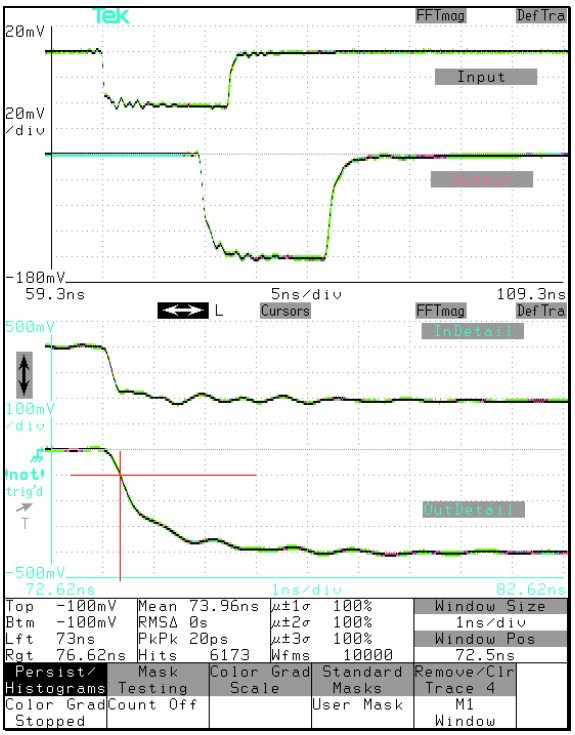
(**) Input signal to each amplifier is scaled according the gain

TAx Fast Pulse / Timing Preamplifier Comparison Sheet x5/x10/x20/x40/x50/x80/x100/x200, DC coupled

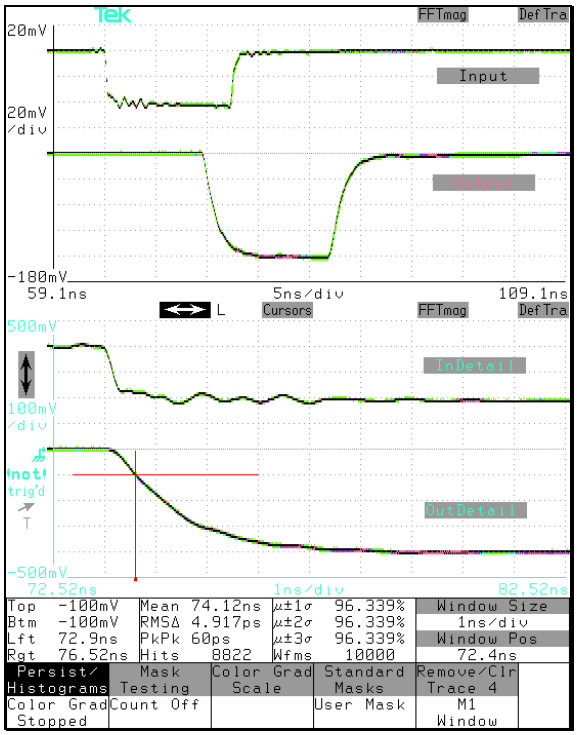
Pulse Response

In the following scope pictures you see the pulse response for negative output signals starting at 0V and falling down to –400mV. The input pulse amplitudes are selected according the gain of each amplifier.

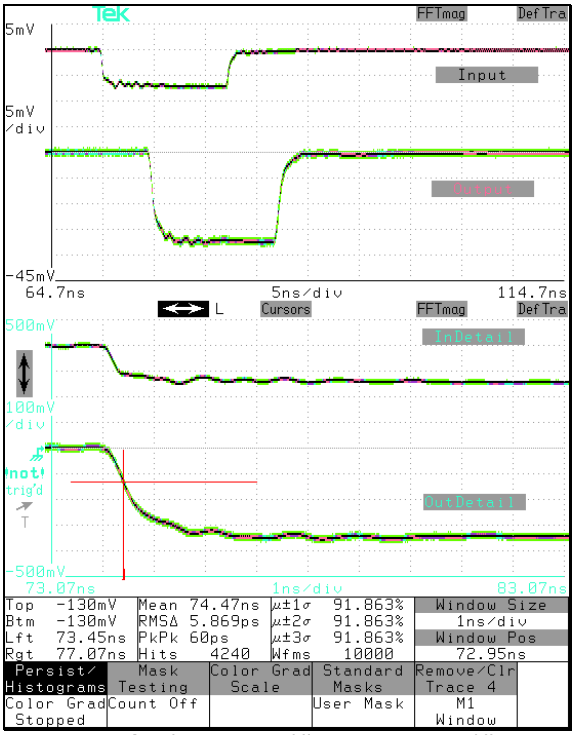
- **0V to -400mV falling edge output**



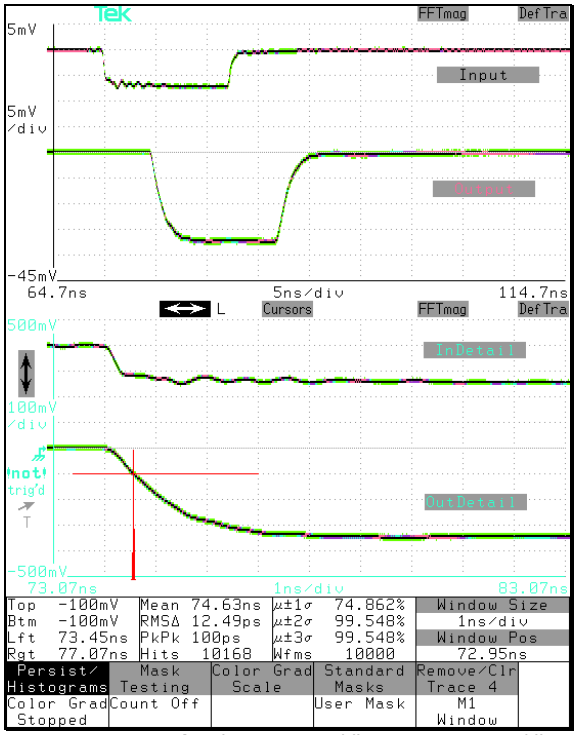
TA1000B-10 (x10), Input 20mV/div, Output 100mV/div



TA1000B-10BWL (x10), Input 20mV/div, Output 100mV/div

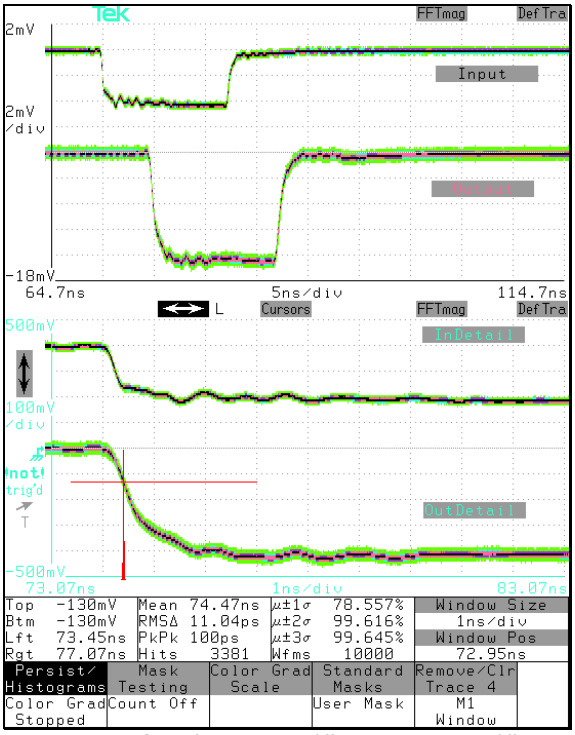


TA1000B-50 (x50), Input 5mV/div, Output 100mV/div

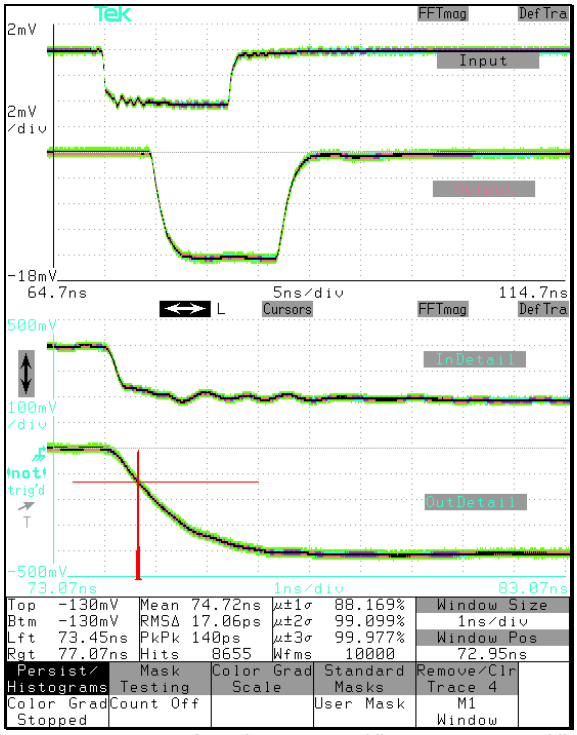


TA1000B-50BWL (x50), Input 5mV/div, Output 100mV/div

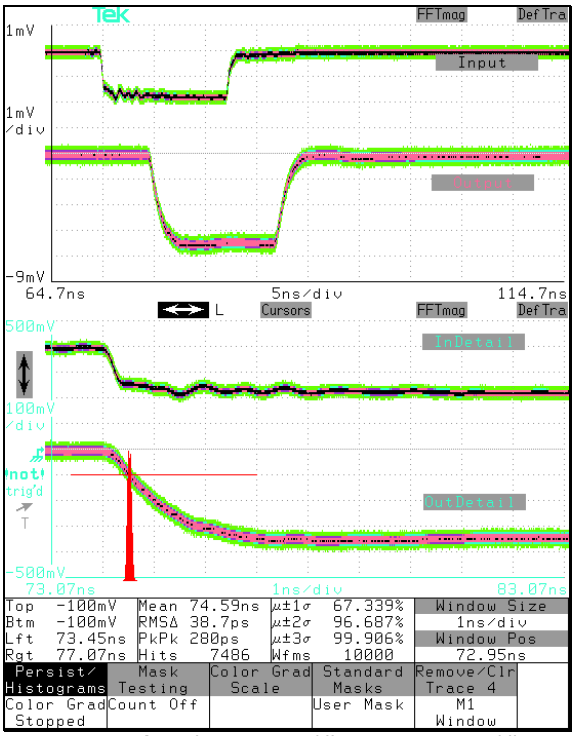
TAx Fast Pulse / Timing Preamplifier Comparison Sheet x5/x10/x20/x40/x50/x80/x100/x200, DC coupled



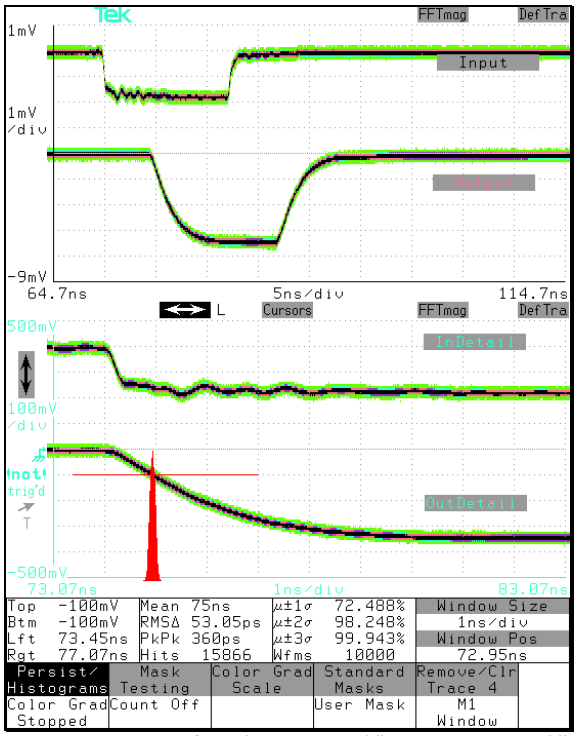
TA1000B-100 (x100), Input 2mV/div, Output 100mV/div



TA1000B-100BWL (x100), Input 2mV/div, Output 100mV/div

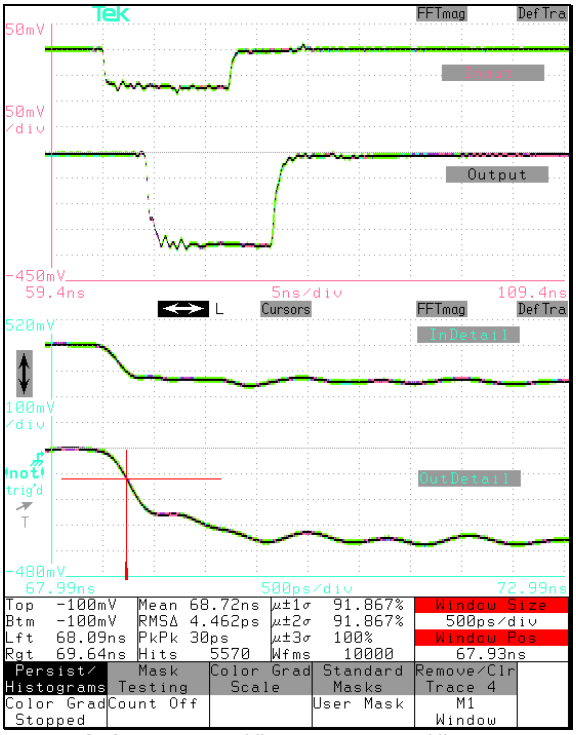


TA1000B-200 (x200), Input 1mV/div, Output 100mV/div

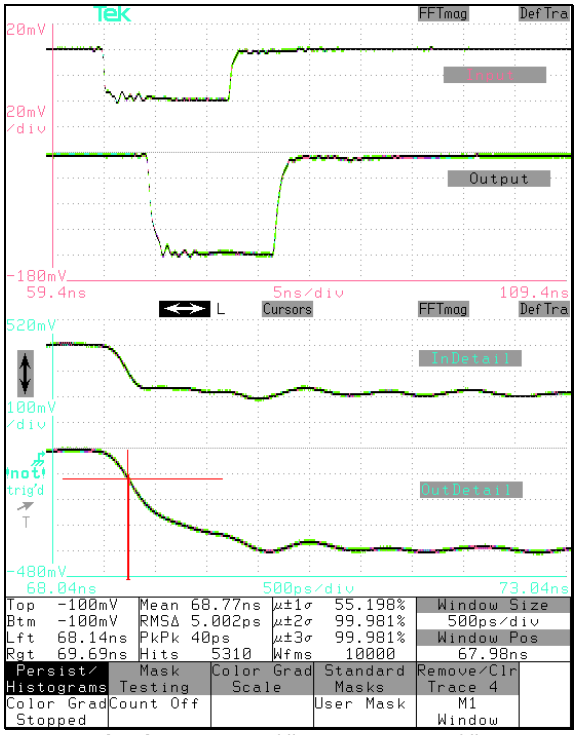


TA1000B-200BWL (x200), Input 1mV/div, Output 100mV/div

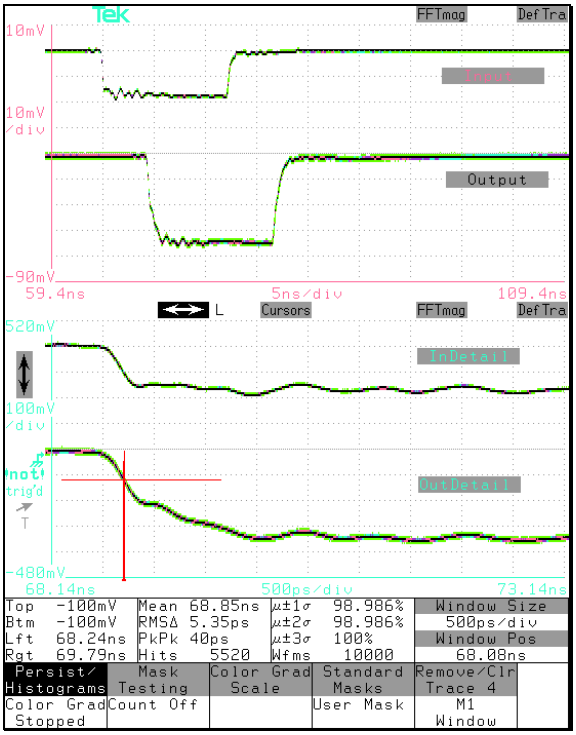
TAx Fast Pulse / Timing Preamplifier Comparison Sheet x5/x10/x20/x40/x50/x80/x100/x200, DC coupled



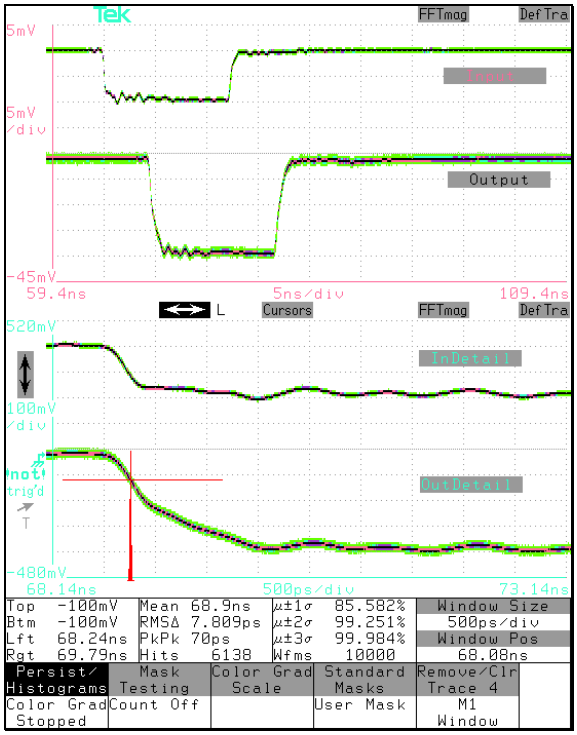
TA2400 (x5), Input 50mV/div, Output 100mV/div



TA1800B (x10), Input 20mV/div, Output 100mV/div

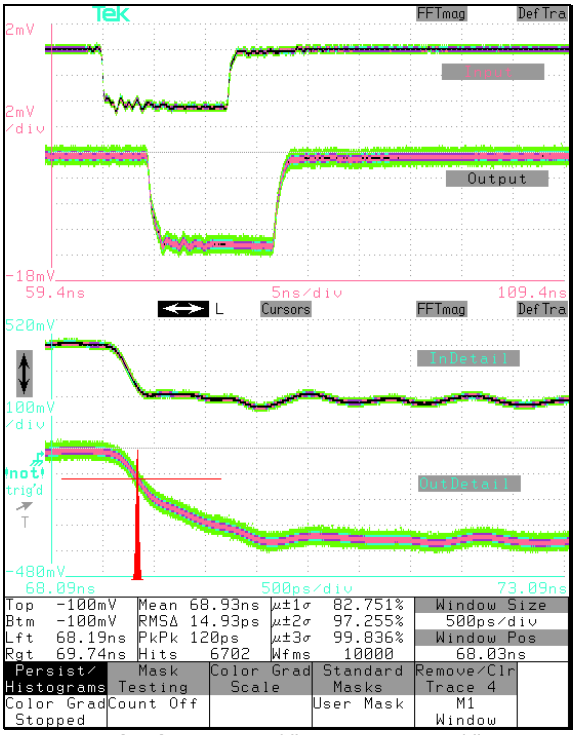


TA2000B-1 (x20), Input 10mV/div, Output 100mV/div



TA2000B-2 (x40), Input 5mV/div, Output 100mV/div

TAx Fast Pulse / Timing Preamplifier Comparison Sheet x5/x10/x20/x40/x50/x80/x100/x200, DC coupled



TA2000B-3 (x80), Input 2mV/div, Output 100mV/div

The lower window of each plot shows details of the corresponding signals in the upper window. There is also a (red colored) histogram of the output signal jitter at a -100mV or –130mV threshold. The jitter's Peak-to-Peak value is visible at "PkPk" and its standard deviation in the "RMSΔ" readout.
This jitter histogram gives a good indication of the timing accuracy and resolution that can be expected.

And, one can very well see that the optimum threshold setting for timing measurements is often not at half of the signal's amplitude but at some other level not too far from idle voltage where the slew rate is at maximum.

TAx Fast Pulse / Timing Preamplifier Comparison Sheet x5/x10/x20/x40/x50/x80/x100/x200, DC coupled

Noise Voltage

First, let me give a short introduction on the common noise specifications of amplifiers and their specific meaning. Generally, random noise voltages add algebraically. In other words, you can only add noise power or the square of the noise voltages. The noise voltages of an amplifier can be visualized over frequency in a noise density distribution curve expressed in "Volts per root Hertz" (V/$\sqrt{Hz}$). This is typically flat over many decades of frequency and often increasing for low frequencies (typ. <100kHz…1MHz) at an 1/f rate. The total noise power is determined by squaring this noise density curve and integrating it over the used frequency range. Metaphorically speaking, it is the area below the V^2/Hz density curve. Important is, that the 1/f noise can be safely neglected when the amplifier bandwidth is high compared to the 1/f corner. Thus, ac-coupling with a low frequency cut-off below 1MHz will not improve the total noise.

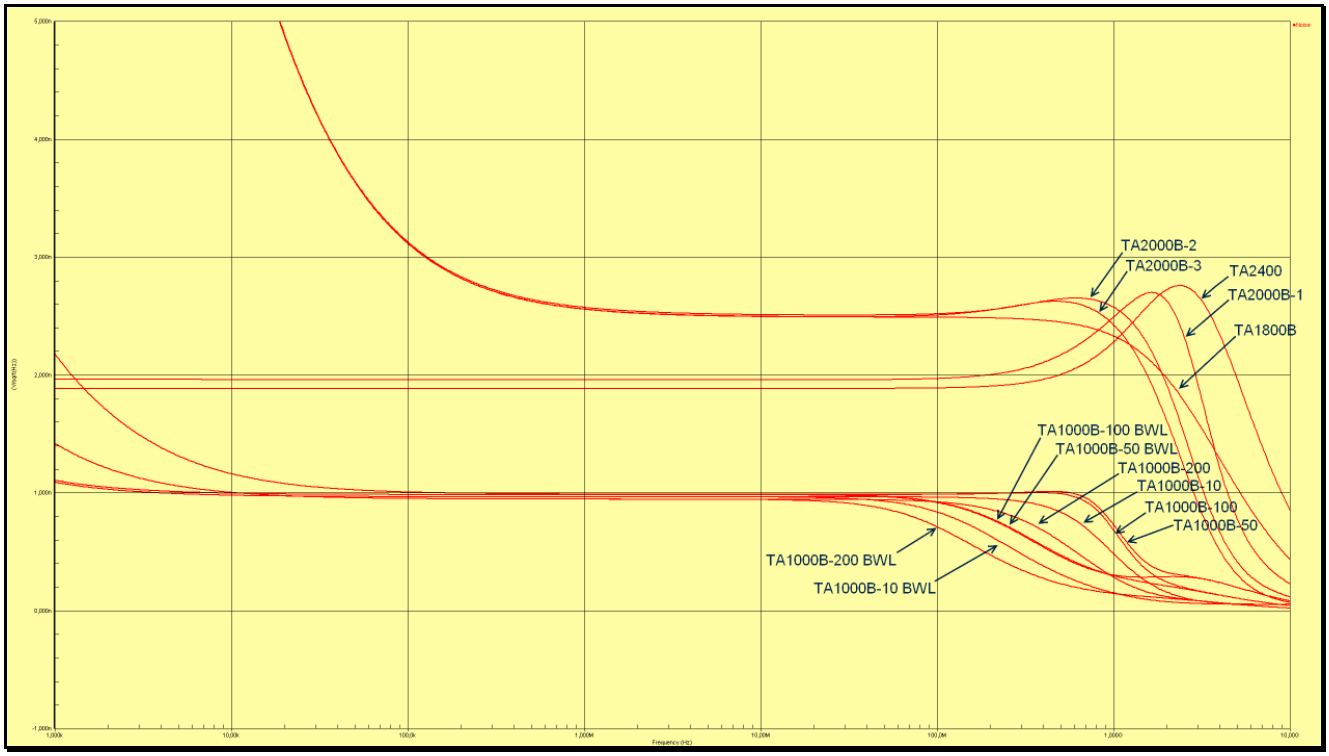
Most often, noise is given input referred. This means, the noise voltage at the output is divided by the amplifier gain. Thus, it is looked at like a noise source at the input of a noise free amplifier.

In datasheets you often find a "*total input referred noise density*" value at a given frequency (e.g. TA1800B: 2.5 nV/$\sqrt{Hz}$ at 1MHz).

Then, there is a "*total low frequency noise*" (e.g. TA1800B: 2.5μV_{rms} in a 20Hz…1MHz bandwidth). This is mostly a measure for the 1/f noise.

"*NOISE FIGURE*", NF is the logarithm ratio of the output and input signal-to-noise ratios at a given frequency (e.g. TA1800B: NF = 16dB at 100MHz). So, it is a measure on how the signal-to-noise power ratio is worsened by the amplifier or how much noise power is added by the amplifier itself. Note that it is very much dependent on source resistance.

A good introduction to noise specs is "Noise Specs Confusing?", National Semiconductor application note AN104, available for download at the website of National Semiconductor.

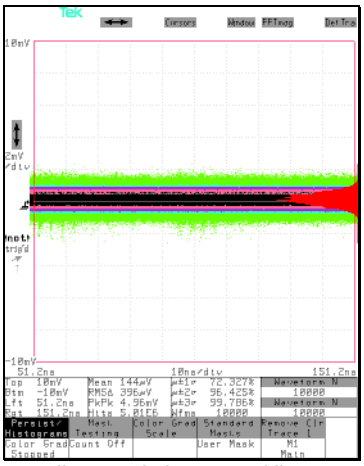


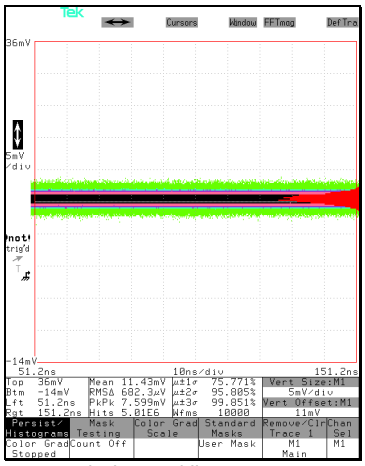
Simulation Results of Input referred Voltage Noise Density of TAx Amplifiers

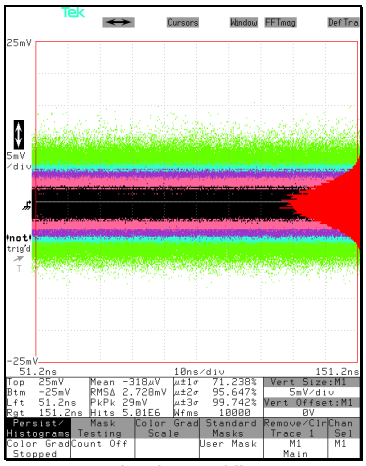
TAx Fast Pulse / Timing Preamplifier Comparison Sheet x5/x10/x20/x40/x50/x80/x100/x200, DC coupled

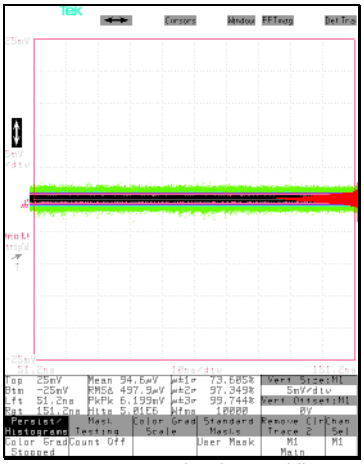
- **Max. Output Noise Voltage**

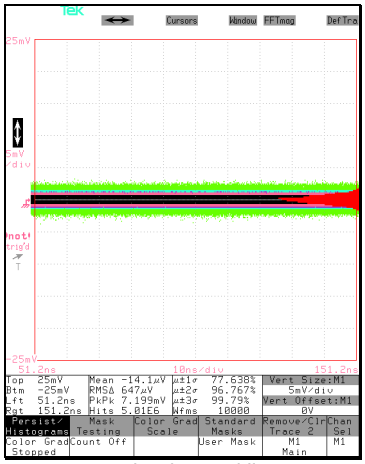
Normally the noise is given input referred, so to speak, it can be compared to the source signal levels. For timing applications it is often more depicting to plot the total output noise of an amplifier.
In the following scope pictures the output noise voltage of our TAx-amplifiers is accumulated over 10,000 waveforms corresponding to about 40 minutes of measurement time. Used was a TEK11801C digital sampling scope with a 12.5GHz sampling head. Thus, the displayed noise voltage is accumulated over a long period and also over the full bandwidth of each amplifier. The TAx's inputs were shortened, i.e. $Z_{Source} = 0\Omega$.

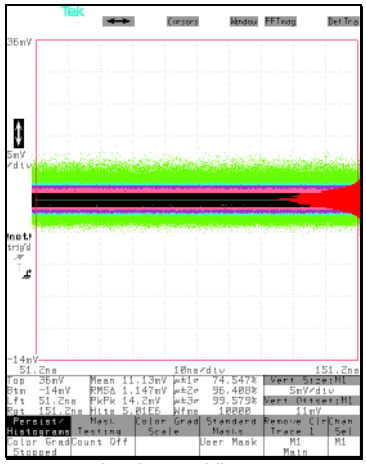

Sampling Head alone, 2mV/div

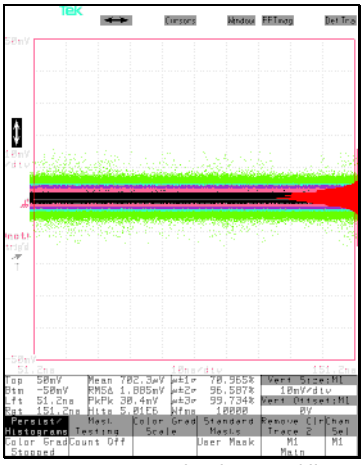

TA2400 (x5), 5mV/div

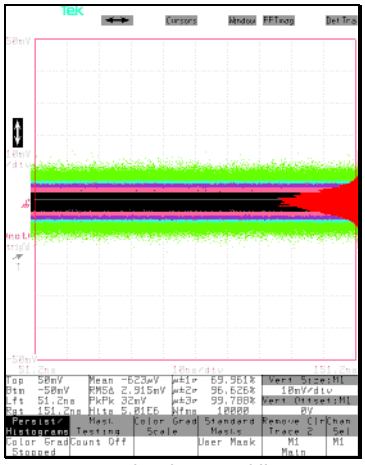

TA2000B-1 (x20), 5mV/div

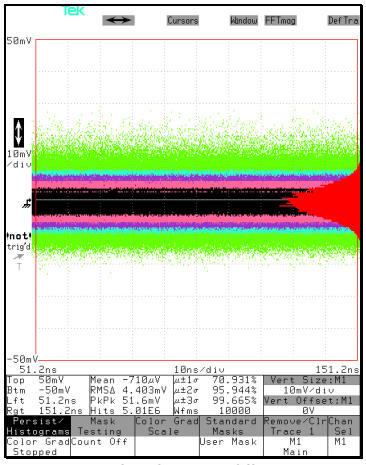

TA1000B-10 BWL (x10), 5mV/div


TA1000B-10 (x10), 5mV/div


TA1800B (x10), 5mV/div


TA1000B-50 BWL (x50), 10mV/div


TA1000B-50 (x50), 10mV/div


TA2000B-2 (x40), 10mV/div

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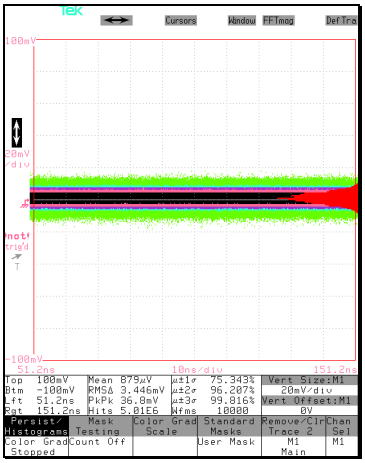
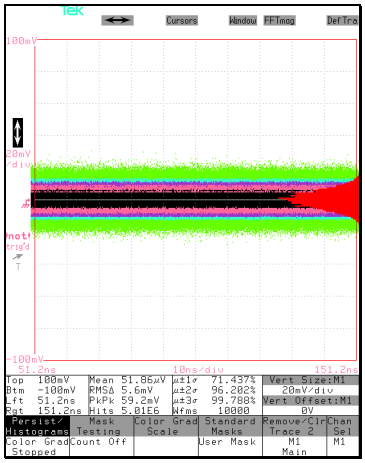
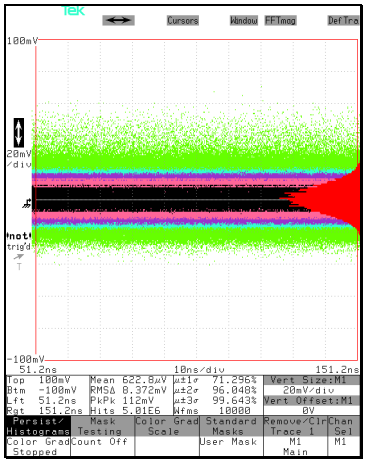


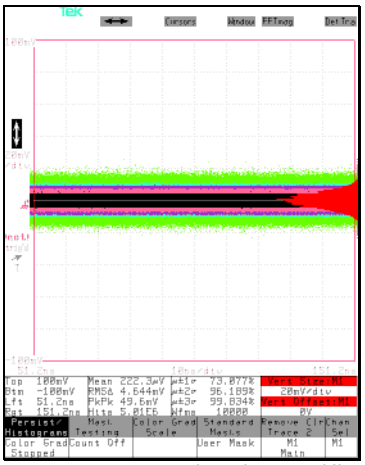
TA1000B-100 BWL (x100), 20mV/div



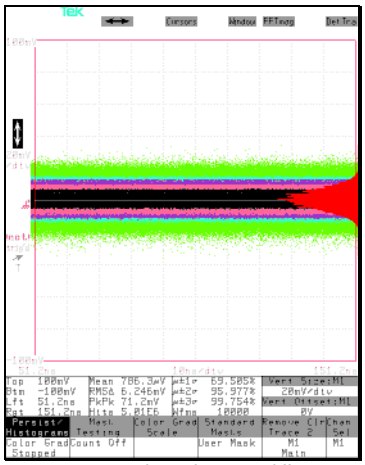
TA1000B-100 (x100), 20mV/div



TA2000B-3 (x80), 20mV/div



TA1000B-200 BWL (x200), 20mV/div



TA1000B-200 (x200), 20mV/div

On the right side of each plot you can see a (red colored) histogram of all the voltage samples in the respective picture. This gives the probability distribution of the noise voltage levels. And, you can find some analysis data on the respective voltage distribution: **Mean** = average value, **RMSΔ** = σ = standard deviation, **PkPk** = Peak-to-Peak voltage = max. – min. sample voltage, **μ ± 1σ** = percentage of samples that fall within ±1 standard deviation of the mean (.±2σ, ±3σ respectively).

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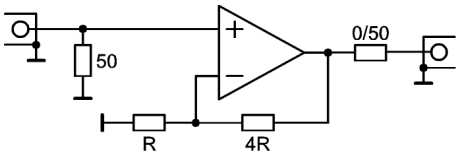
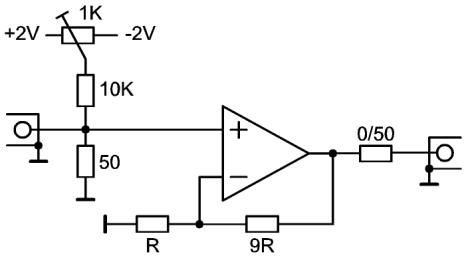
Simplified Circuit Diagrams

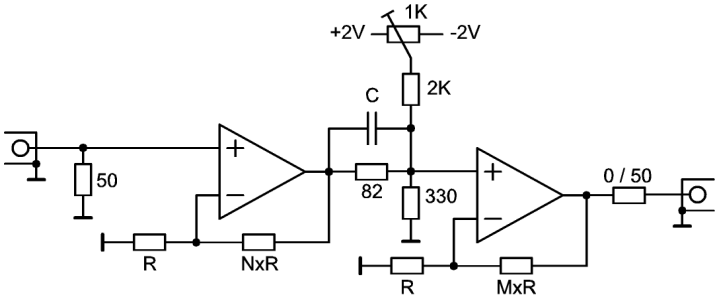
- **TA2400:**



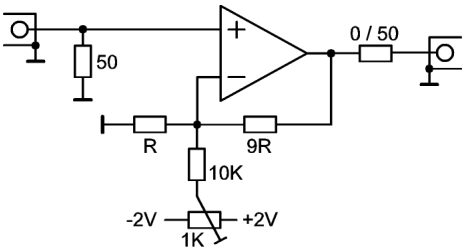
- **TA1800B:**



- **TA2000B-1/-2/-3:**



- **TA1000B-10:**



- **TA1000B-50/-100/-200:**