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Performance-Test Results of the CLAS Pre-amplifiers-CP01

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Introduction: The pre-amplifiers for the CLAS drift chambers, CP01, are being delivered in lots. Each lot contains between 500 and 2500 pre-amplifiers. A total of 42,078 pre-amplifiers have been received in 33 lots. To determine the performance characteristics of the pre-amplifiers of a given lot, tests were conducted on random samples of pre-amplifiers taken from that lot. In this paper we present the results of the performance tests for all the 33 lots.

Setup: The input pulse to the pre-amplifier was generated by a precision pulse-generator (Tektronix HFS 9030). Since the minimum output voltage of the pulser was larger than the specified input voltage for the pre-amplifier, an attenuator was used to reduce the output voltage of the pulser to the specified value. The output of the pre-amplifier was sent to the Tektronix TDS 644A digitizing oscilloscope. LabVIEW was used to acquire data from the oscilloscope. Microsoft Excel was used to create spreadsheets. SigmaPlot was used to generate the graphs. See Figure 1 for details of the setup.

Procedure: We took random samples of 121 or more pre-amplifiers from each lot. We measured the output amplitude and the output rise time of each pre-amplifier. The output data of the pre-amplifiers were automatically recorded. The measured values of the output amplitude and of the output rise time were averages of 20 individual measurements. Since the reading accuracy of the oscilloscope at the 50 mV/Div. setting is $\pm 1.5\%$, the precision of the measured average value is $\pm 0.34\%$. The input pulse characteristics are given in Figure 1.

To measure the linearity, the input voltage was varied from 50—300 mV in intervals of 50 mV (other pulse characteristics remaining constant). Above 300 mV, we changed the input voltage in 25 mV intervals until we reached 375 mV.

Data Analysis: We determined the mean output amplitude, the mean output rise time, the mean gain, the standard deviations (SD) and the standard deviations of the means (SDOM) of the samples taken from each lot. In Table 1 we present, for all the lots, the measured mean amplitudes, the standard deviations of the amplitudes, the measured mean rise times and the standard deviations of the rise times. Table 2 shows, for the specified input pulse, scaled output amplitudes normalized to 100 mV input amplitude, maximum and minimum deviations of the output amplitudes (in percent) from the design output value of 200 mV, and the estimated percentage of pre-amplifiers of the lot population, which could have an output greater than 195 mV—the minimum output requirement. Table 3 shows the same type of data for the rise

time. The results for gain are shown in Table 4. Figures 2--4 show the cumulative distributions of the amplitude, rise time, and gain respectively. Figure 5 shows a scatter plot of the measured amplitude versus measured rise time of all the sampled pre-amplifiers. A scatter plot of measured mean amplitudes versus measured mean rise times (for all the 33 lots) is shown in Figure 6. The data for the linearity test is shown in Table 5 and in Figure 7.

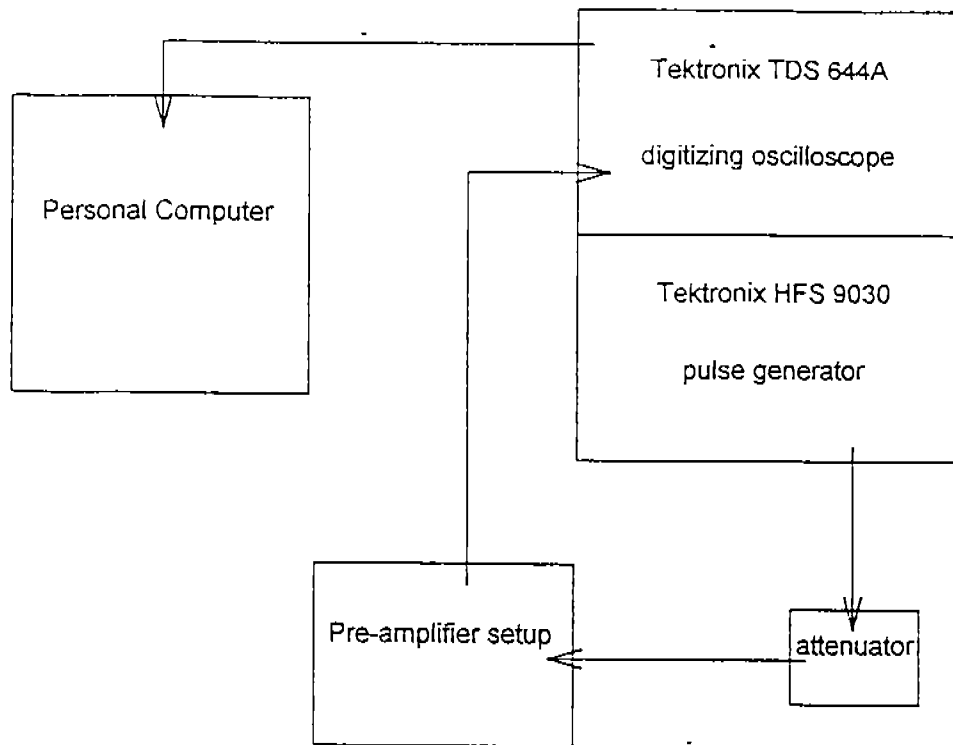
Results: The estimated number of pre-amplifiers in a lot, as a percentage of the lot population, which could have an output amplitude greater than 195 mV is given in Table 2. We note that three lots (lot # 1005-2d, 1004-2, and 1004-4) have poor output amplitude response. From Figure 2, we estimate the mean of the measured output amplitude (of all sampled pre-amplifiers) to be 203 mV. The standard deviation (SD) and the standard deviation of the mean (SDOM) are estimated to be 5 mV and 0.1 mV respectively.

We have estimated (Table 3) the number of pre-amplifiers in a lot, as a percentage of the lot population, which have an output rise time less than 3.9 ns. From Figure 3 we determined the average of the measured output rise time (of all sampled pre-amplifiers) to be 4.33 ns. The standard deviation (SD) and the standard deviation of the mean (SDOM) are estimated to be 0.19 ns and 0.003 ns respectively. From the data we note that the output rise time is independent of the input rise time which has varied between 1.3 ns and 2.3 ns.

From Figure 4 we estimate the mean gain (of all sampled pre-amplifiers) to be 2.30 mV/ μ A. The standard deviation (SD) and the standard deviation of the mean (SDOM) are estimated to be 0.09 mV/ μ A and 0.001 mV/ μ A respectively.

The linearity tests indicate a region of linearity between 25 μ A-160 μ A.

Experimental Setup



INPUT PULSE

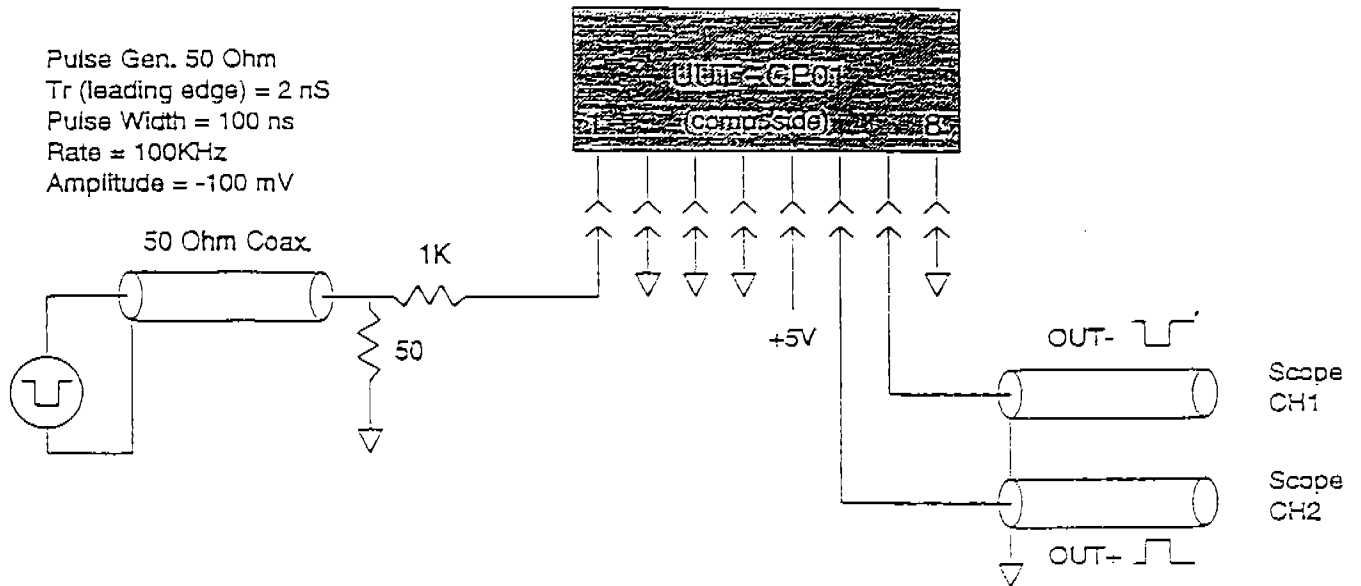


Figure 1

MEASURED AMPLITUDE AND MEASURED RISE TIME

Lot	Box	Qty	Sample Size	Mean Amplitude (mV)	SDOA (mV)	Mean Rise Time (s)	SDOT (s)
1004-1	1	2479	256	202	2	4.37E-09	1.30E-10
1002-2	2	1099	121	203	3	4.31E-09	1.23E-10
1002-4	2	837	121	202	3	4.33E-09	1.19E-10
1003-1	2	1488	169	203	2	4.39E-09	1.00E-10
1003-2	2	1441	144	204	1	4.31E-09	8.61E-11
1003-3	2	1514	169	202	3	4.28E-09	1.33E-10
1003-4	2	1687	169	202	3	4.42E-09	1.28E-10
1001-7	3	1159	121	201	3	4.46E-09	1.16E-10
1001-8	3	1140	121	197	3	4.52E-09	8.25E-11
1001-10	3	1091	121	201	3	4.48E-09	1.78E-10
1002-1	3	769	121	201	3	4.43E-09	1.29E-10
1002-3	3	1019	121	201	3	4.36E-09	1.22E-10
1001-3	4	1113	121	203	2	4.31E-09	8.99E-11
1001-4	4	1184	121	204	2	4.35E-09	7.23E-11
1001-5	4	1137	121	202	3	4.38E-09	7.93E-11
1001-6	4	1140	121	202	3	4.33E-09	6.83E-11
1005-2d	5	1020	121	197	5	4.13E-09	1.03E-10
1004-a	6	1490	169	198	2	4.25E-09	9.27E-11
1004-b	6	1481	169	202	4	4.38E-09	8.82E-11
1005-a	7	1935	196	196	3	4.18E-09	9.57E-11
1005-b	7	1221	144	196	3	4.24E-09	1.26E-10
1005-c	7	1481	169	196	7	4.19E-09	1.00E-10
1004-	8	1017	121	202	3	4.40E-09	9.06E-11
1004-	9	969	121	198	3	4.28E-09	1.02E-10
1004-1	9	1165	121	198	4	4.46E-09	1.23E-10
1004-2	9	1118	121	198	3	4.21E-09	8.58E-11
1004-3	9	1161	121	199	3	4.38E-09	9.94E-11
1004-4	9	1151	121	200	3	4.30E-09	1.19E-10
1004-5	9	1341	144	197	4	4.24E-09	9.64E-11
1001-1	10	1141	121	202	2	4.34E-09	9.59E-11
1001-2	10	1098	121	202	2	4.35E-09	9.80E-11
1004-a	11	1485	169	198	3	4.27E-09	7.33E-11
1004-b	11	1507	169	197	3	4.18E-09	1.19E-10
Total Pre-amplifiers:				42078			
Total Pre-amplifiers tested:				4656			
SDOA: Standard Deviation Of the Amplitude							
SDOT: Standard Deviation Of the rise Time							

TABLE 1

AMPLITUDE

Lot	Box	Qty	Input	Mean Meas.	SDOA	Scaled	% above	PDDA	
				Amplitude		Amplitude	195 mV	Pos	Neg
				(mV)	(mV)	(mV)			
1004-1	1	2479	96	202	2	210	99.99	8	0
1002-2	2	1099	98	203	3	207	99.99	6	0
1002-4	2	837	96	202	3	210	99.99	6	0
1003-1	2	1488	96	203	2	211	99.99	6	0
1003-2	2	1441	98	204	1	208	99.99	6	0
1003-3	2	1514	98	202	3	206	99.99	6	10
1003-4	2	1687	96	202	3	210	99.99	6	0
1001-7	3	1159	96	201	3	209	99.99	10	0
1001-8	3	1140	96	197	3	205	99.99	6	1.5
1001-10	3	1091	98	201	3	205	99.99	4	2
1002-1	3	769	96	201	3	209	99.99	10	0
1002-3	3	1019	96	201	3	209	99.99	8	0
1001-3	4	1113	98	203	2	207	99.99	6	0
1001-4	4	1184	98	204	2	208	99.99	6	0
1001-5	4	1137	98	202	3	206	99.99	6	4
1001-6	4	1140	98	202	3	206	99.99	7	10
1005-2d	5	1020	104	197	5	189	11.51	1	28
1004-a	6	1490	100	198	2	198	93.32	0	4
1004-b	6	1481	100	202	4	202	95.99	2.5	17
1005-a	7	1935	96	196	3	204	99.99	12	4
1005-b	7	1221	96	196	3	204	99.99	4	2.5
1005-c	7	1481	96	196	7	204	90.15	8	32
1004-	8	1017	100	202	3	202	99.01	2	4
1004-	9	969	100	198	3	198	84.13	0	6
1004-1	9	1165	100	198	4	198	77.34	4	10
1004-2	9	1118	103	198	3	192	15.87	0	9
1004-3	9	1161	100	199	3	199	90.82	2	4
1004-4	9	1151	103	200	3	194	37.07	0	7
1004-5	9	1341	100	197	4	197	69.15	0	10
1001-1	10	1141	100	202	2	202	99.99	4	0
1001-2	10	1098	100	202	2	202	99.99	4	4
1004-a	11	1485	100	198	3	198	84.13	2	12
1004-b	11	1507	100	197	3	197	74.86	0	8

PDDA: Percent Deviation from Design Amplitude

TABLE 2

RISE TIME

Lot	Box	Input	Meas.	SDOT	% less than	PDDT	
		Signal (ns)	Output (ns)	(ns)	3.9 ns	Pos.	Neg.
1004-1	1	2.15	4.37	0.130	<1%	462.500	0.000
1002-2	2	2.20	4.31	0.123	<1%	42.188	0.000
1002-4	2	2.15	4.33	0.119	<1%	43.750	0.000
1003-1	2	2.15	4.39	0.100	<1%	45.313	0.000
1003-2	2	2.15	4.31	0.086	<1%	42.188	0.000
1003-3	2	2.15	4.28	0.133	<1%	57.813	0.000
1003-4	2	2.20	4.42	0.128	<1%	46.875	0.000
1001-7	3	2.20	4.46	0.116	<1%	46.875	0.000
1001-8	3	2.20	4.52	0.083	<1%	46.875	0.000
1001-10	3	2.15	4.48	0.178	<1%	68.750	0.000
1002-1	3	2.20	4.43	0.129	<1%	45.313	0.000
1002-3	3	2.20	4.36	0.122	<1%	45.313	0.000
1001-3	4	2.15	4.31	0.090	<1%	42.188	0.000
1001-4	4	2.15	4.35	0.072	<1%	42.188	0.000
1001-5	4	2.15	4.38	0.079	<1%	42.188	0.000
1001-6	4	2.20	4.33	0.068	<1%	40.625	0.000
1005-2d	5	2.15	4.13	0.103	1.29%	40.625	0.000
1004-a	6	1.25	4.25	0.093	<1%	40.625	0.000
1004-b	6	1.35	4.38	0.088	<1%	53.125	0.000
1005-a	7	2.15	4.18	0.096	<1%	37.500	0.000
1005-b	7	2.15	4.24	0.126	<1%	42.188	0.000
1005-c	7	2.15	4.19	0.100	<1%	39.063	0.000
1004-	8	1.30	4.40	0.091	<1%	45.313	0.000
1004-	9	1.30	4.28	0.102	<1%	42.188	0.000
1004-1	9	1.30	4.46	0.123	<1%	46.875	0.000
1004-2	9	2.15	4.21	0.086	<1%	39.063	0.000
1004-3	9	1.35	4.38	0.099	<1%	43.750	0.000
1004-4	9	2.10	4.30	0.119	<1%	42.188	0.000
1004-5	9	1.35	4.24	0.096	<1%	40.625	0.000
1001-1	10	1.30	4.34	0.096	<1%	42.188	0.000
1001-2	10	1.35	4.35	0.098	<1%	51.563	0.000
1004-a	11	1.30	4.27	0.073	<1%	40.625	0.000
1004-b	11	1.35	4.18	0.119	<1%	56.250	0.000
SDOT: Standard Deviation Of the rise Time							
PDDT: Percent Deviation from Design rise Time							

TABLE 3

Frequency v. Amplitude

(all sampled pre-amplifiers)

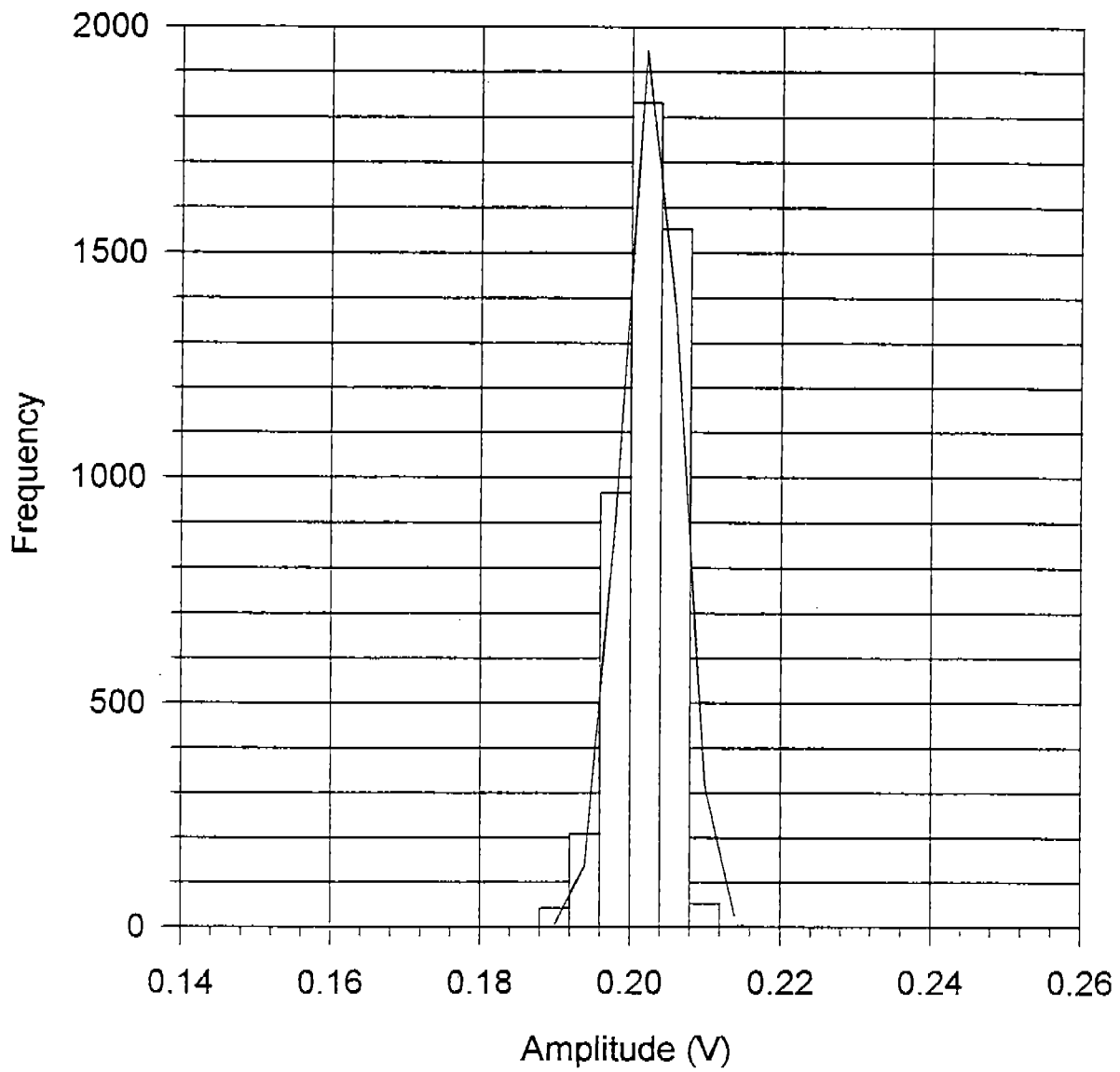


Figure 2

Frequency v. Rise Time (all sampled pre-amplifiers)

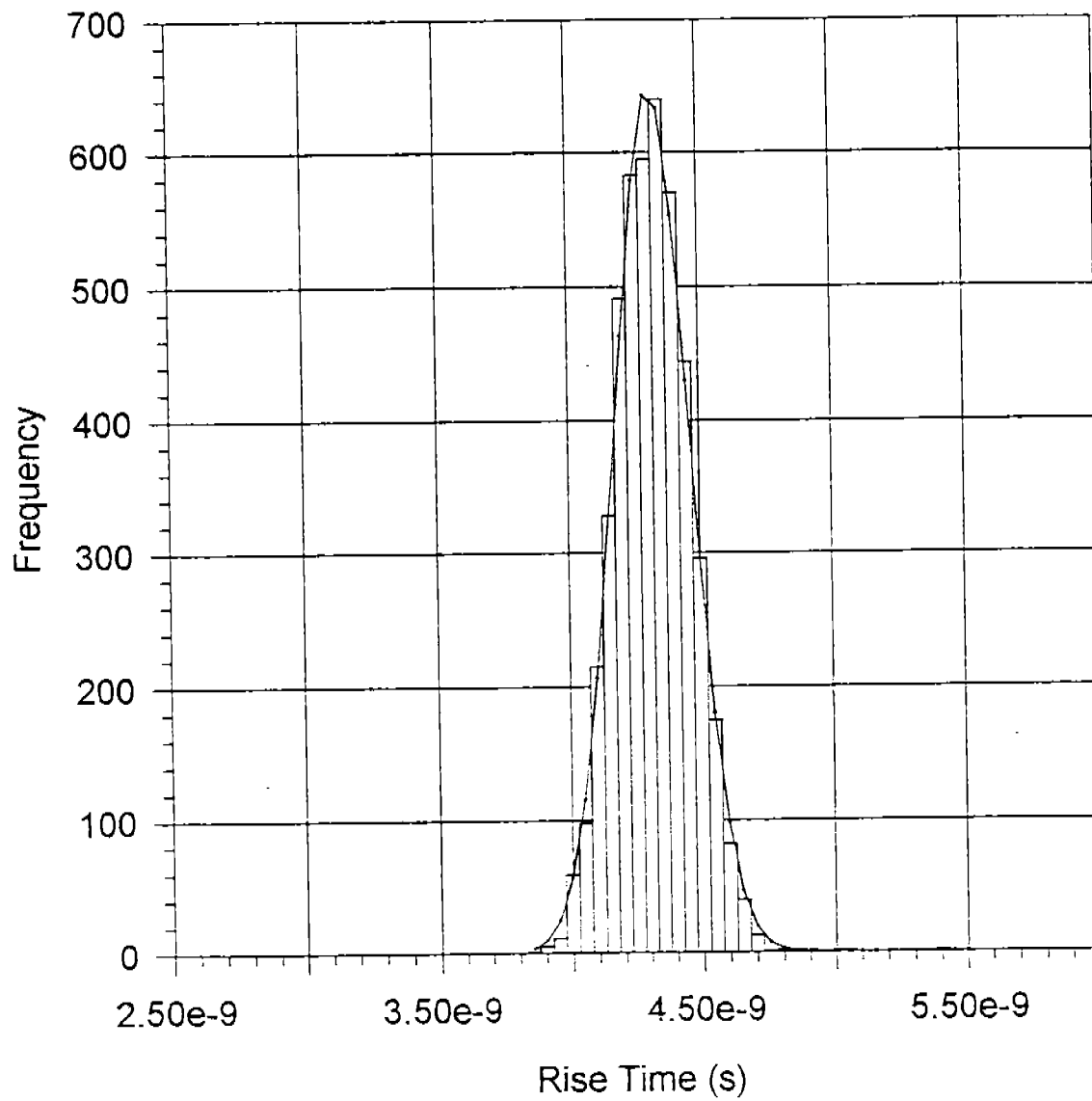


Figure 3

Frequency v. Gain (all sampled pre-amplifiers)

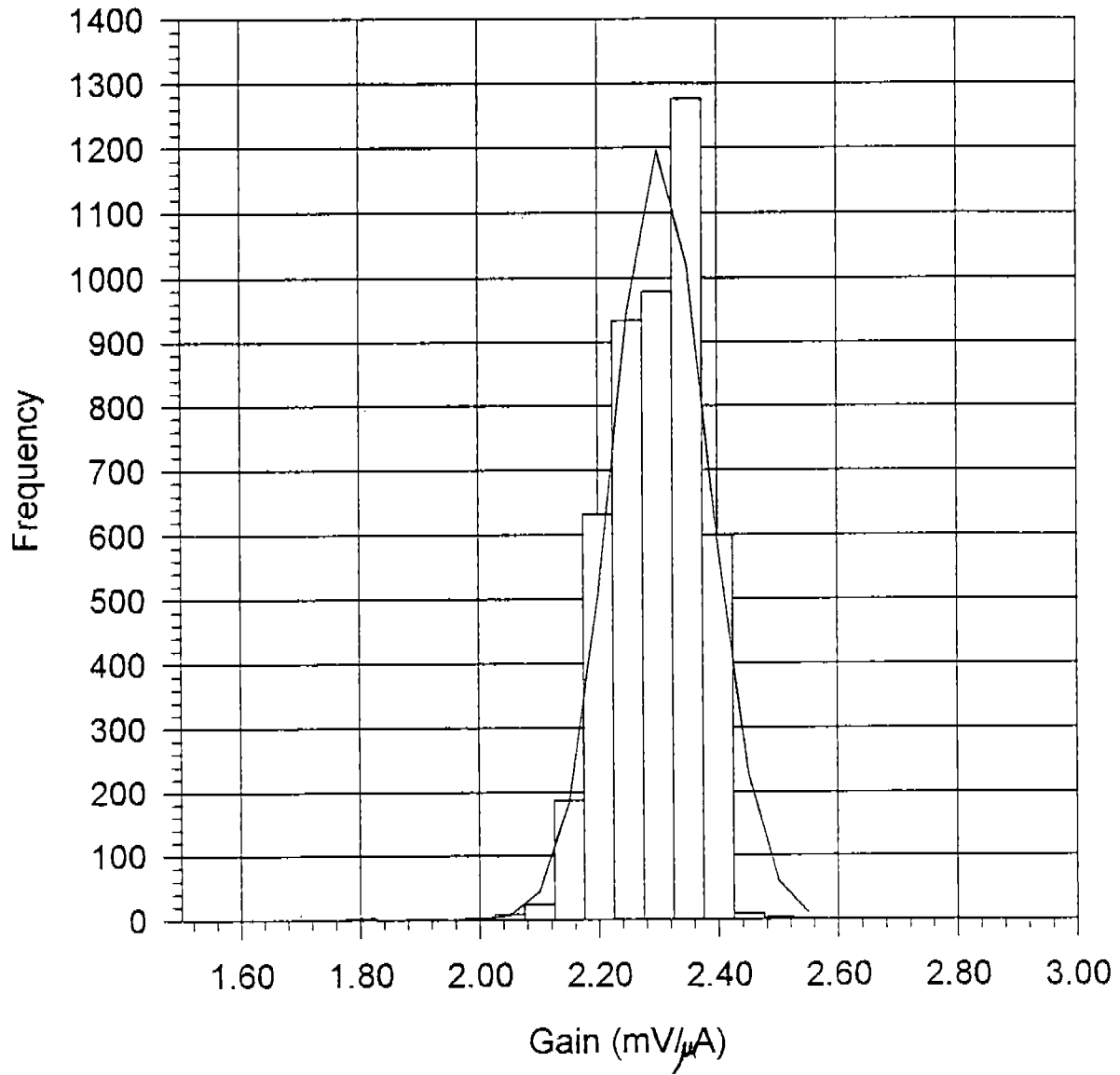


Figure 4

Measured Rise Time v. Measured Amplitude (all pre-amplifiers)

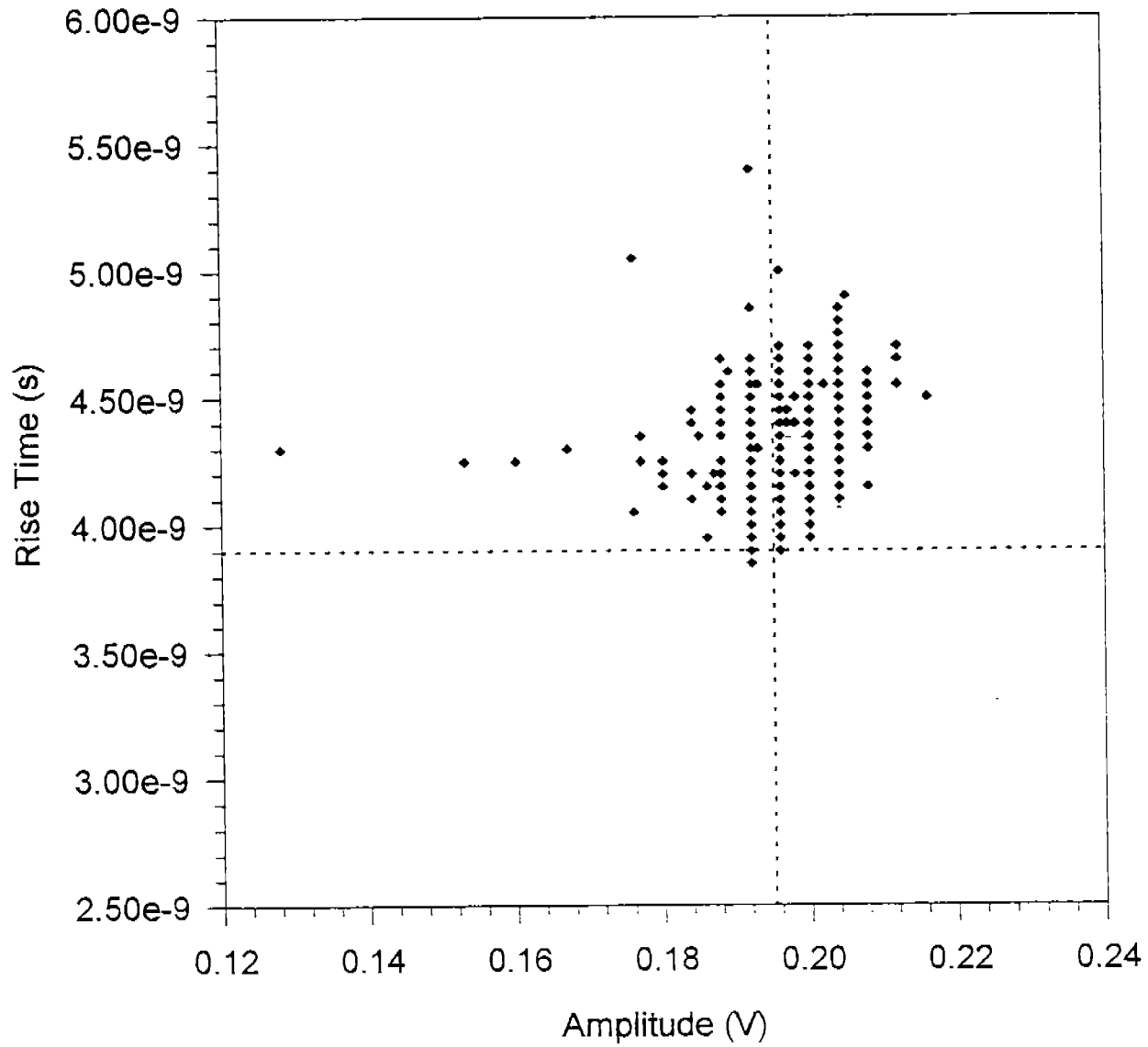


Figure 5

Measured Rise Time vs. Measured Amplitude (mean values)

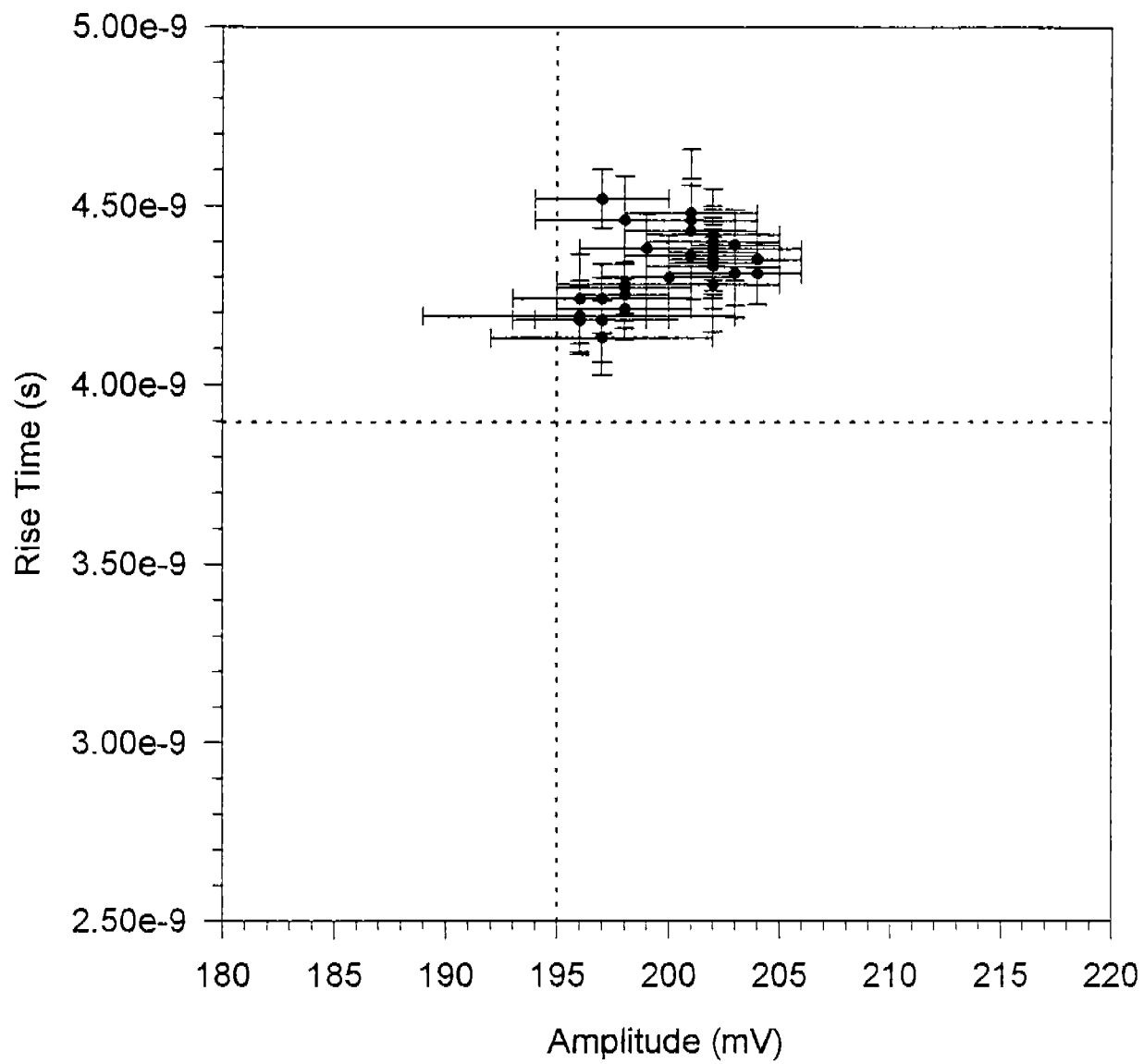


Figure 6

LINEARITY (batch 1001-8)

Input Amplitude (V)	Mean Output Amplitude (V)	SDOM (V)
0.050	0.104	0.004
0.100	0.197	0.003
0.150	0.280	0.001
0.200	0.328	0.000
0.250	0.360	0.001
0.300	0.378	0.001
0.325	0.381	0.001
0.350	0.384	0.002
0.375	0.386	0.002
SDOM: Standard Deviation Of the Mean		

TABLE 5

Linearity
batch 1001-8

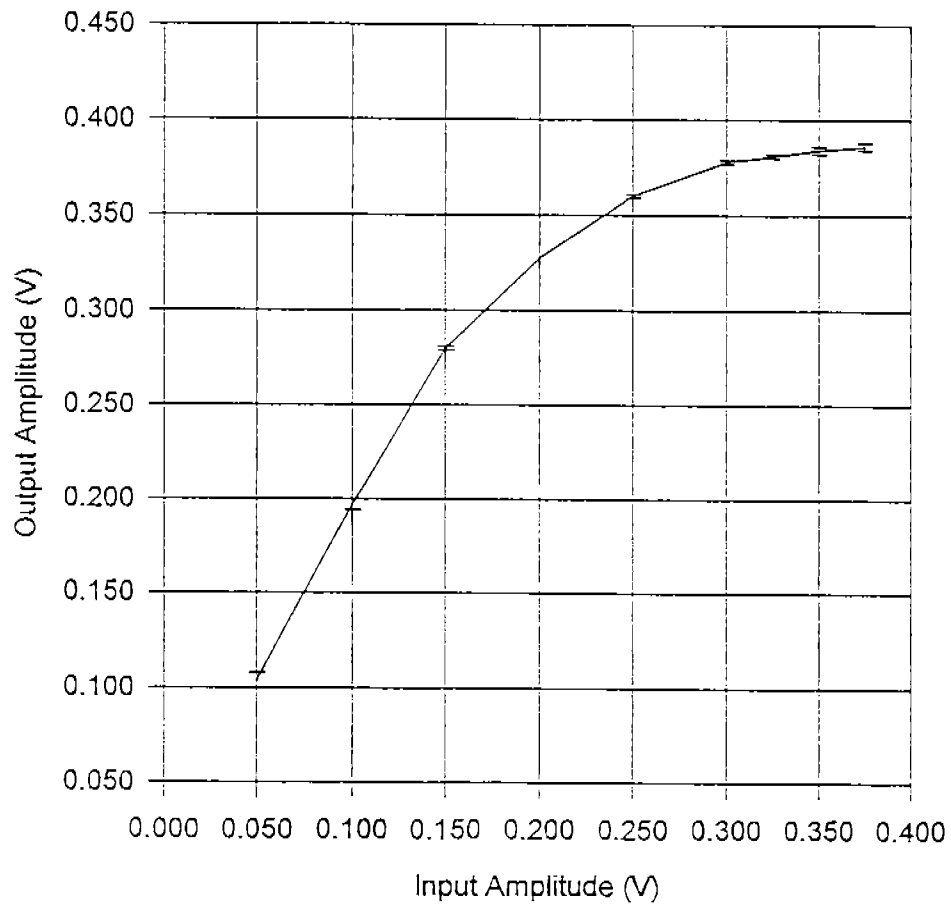


Figure 7